SIPROTEC
Numerical Protection Relays

Protection
Systems

Catalog
SIP · 2006

SIEMENS

SIPROTEC – more than just protection

This is the latest edition of the printed SIPROTEC Catalog. This edition – which is now available – contains many suggestions by our readers, along with information regarding innovations and supplementary products. The SIPROTEC Catalog is also available on CD ROM.

One of the highlights is the SIPROTEC protection relays with IEC 61850 communication. IEC 61850 was created by protection experts and manufacturers alike. The goal of this standard is to achieve an object-oriented communication structure within substations. SIPROTEC protection relays and bay control units are the first to feature the IEC 61850 standard. With the substation configurator, a part of DIGSI 4, SIPROTEC units as well as other makes can be configured in accordance with IEC 61850.

Meet the standard
IEC 61850

This SIPROTEC Catalog is supplemented by multimedia computer animation tools.

+ CD-ROM "SIPROTEC 4 you – Features, Applications, Relays"

+ CD-ROM "SIPROTEC 4 you – Start Up".

+ CD-ROM "SIPROTEC 4 you – IEC 61850 & ETHERNET".

+ CD-ROM "SIGRA 4 you"

You can order the printed SIPROTEC Catalog (and all the CD ROMs) via the Internet free of charge. Please fill in a form at www.siprotec.com/catalog. You may also ask your Siemens representative or send us an e-mail (support.energy@siemens.de).

This catalog will assist you by increasing your understanding of our products and therefore help you to optimally and conveniently apply the available features and functionality. We wish you a pleasant and productive experience with SIPROTEC.

Paulo Ricardo Stark
Vice President
Power Transmission and Distribution – Energy Automation
Protection Systems Division
"We ensure reliability in energy supply."

ONE bay, ONE IED (Intelligent Electronic Device)
Siemens is the world market leader in delivering combined protection & control relays. We provide control functionality with the CFC (Continuous function chart), which is accepted as state-of-art in industrial automation (SIMATIC STEP 7) and makes the life for the protection engineers easier.

ONE DIGSI
Parameterization Software serves all protection products Siemens is the first supplier to meet this strong customer demand to have one software for all protection products. DIGSI can handle previous versions and the busbar protection while providing unrivalled functionality.

ONE single source for all products and services
Siemens provides a full product range for all market segments. In order to provide optimal services we have concentrated resources for important functions, e.g. one product management, one product development, one factory, etc. We will support you in planning, engineering, commissioning, relay co-ordination, type test, etc. all over the world.

SIEMENS

SIPROTEC
Numerical Protection Relays

Catalog SIP · 2006

Supersedes Catalog SIP · 2004

Contents

Product Selection

Page

Relay Functions

Protection functions	Type	7SA522	7SA6	7SD600	7SD5	7SD610	7SJ45	7SJ46	7SJ600	7SJ602	7SJ61	7SJ62	7SJ63	7SJ64	7VH60	7UT612	7UT613	7UT63	7SS60	7SS52
		Distance		Pilot wire differential / Line differential			Overcurrent								Differential					
ANSI No.*	Description																	–		
14	Locked rotor protection	–	–	–	–	–	–	–	–	–	●	●	●	●	–	–	–	–	–	–
21	Distance protection, phase	■	■	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21N	Distance protection, earth (ground)	■	■	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
21FL	Fault locator	■	■	–	●	–	–	–	–	–	–	●	●	●	–	–	–	–	–	–
24	Overfluxing (*V*/*f* protection)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	●	●	–	–
25	Synchronizing, synchronism check	●	●	–	●	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–
27	Undervoltage	●	●	–	●	–	–	–	–	–	–	●	●	●	–	–	–	●	–	–
27/34	Stator earth-fault 3rd harmonic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
32	Directional power	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	●	–	–
32F	Forward power	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–
32R	Reverse power	–	–	–	–	–	–	–	–	–	–	–	–	●	–	–	–	–	–	–
37	Undercurrent or underpower	–	–	–	–	–	–	–	–	●	■	■	■	■	–	–	–	–	–	–
40	Loss of field	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
46	Load unbalance, negative phase-sequence overcurrent	–	–	–	–	–	–	–	■	■	■	■	■	■	–	●	–	●	–	–
47	Phase-sequence voltage	■	■	–	■	–	–	–	–	–	–	■	■	■	–	–	–	–	–	–
48	Motor starting protection	–	–	–	–	–	–	–	■	●	●	●	●	●	–	–	–	–	–	–
49	Thermal overload	–	●	–	■	■	–	–	■	■	■	■	■	■	–	■	■	■	–	–
49R	Rotor thermal protection	–	–	–	–	–	–	–	■	■	■	■	■	■	–	–	–	–	–	–
49S	Stator thermal protection	–	–	–	–	–	–	–	■	■	■	■	■	■	–	–	–	–	–	–
50	Instantaneous overcurrent	■	■	■	■	■	■	■	■	■	■	■	■	■	–	■	■	■	–	●
50N	Instantaneous earth-fault overcurrent	■	■	–	■	■	–	–	■	■	■	■	■	■	–	■	■	■	–	●
50BF	Breaker failure	●	●	–	■	●	–	–	–	■	■	■	■	■	–	●	●	●	–	■
51GN	Zero speed and underspeed device	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
51	Overcurrent-time relay, phase	■	■	■	■	■	■	■	■	■	■	■	■	■	–	■	■	■	–	●
51N	Overcurrent-time relay, earth	■	■	–	■	■	■	■	■	■	■	■	■	■	–	■	■	■	–	●
51V	Overcurrent-time relay, voltage controlled	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
59	Overvoltage	●	●	–	●	–	–	–	–	–	–	●	●	●	–	–	–	●	–	–
59N	Residual voltage earth-fault protection	●	●	–	●	–	–	–	–	■	–	■	■	■	–	–	–	–	–	–
59GN	Stator earth-fault protection	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
64	100 % Stator earth-fault protection (20 Hz)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
64R	Rotor earth fault	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

■ Standard function

● Option

* ANSI/EEE C 37.2: IEEE Standard Electrical Power System Device Function Numbers

Protection functions	Type	Generator and motor protection		Breaker management	Synchronizing	Breaker failure	Voltage, frequency
		7UM61	7UM62	7VK61	7VE6	7SV600	7RW600
ANSI No.*	Description				–		
14	Locked rotor protection	■	■	–	–	–	–
21	Distance protection, phase	■	■	–	–	–	–
21N	Distance protection, earth	–	–	–	–	–	–
21FL	Fault locator	–	–	–	–	–	–
24	Overfluxing (*V*/*f* protection)	■	■	–	–	–	■
25	Synchronizing, synchronism check	–	–	■	■	–	–
27	Undervoltage	■	■	●	●	–	■
27/34	Stator earth-fault 3rd harmonic	■	■	–	–	–	–
32	Directional power	–	■	–	–	–	–
32F	Forward power	●	■	–	–	–	–
32R	Reverse power	■	■	–	–	–	–
37	Undercurrent or underpower	–	■	–	–	–	–
40	Loss of field	●	■	–	–	–	–
46	Load unbalance, negative phase-sequence overcurrent	●	●	–	–	–	–
47	Phase-sequence voltage	■	■	–	–	–	–
48	Incomplete sequence, locked rotor	●	●	–	–	–	–
49	Thermal overload	■	■	–	–	–	
49R	Rotor thermal protection	–	■	–	–	–	–
49S	Stator thermal protection	■	■	–	–	–	–
50	Instantaneous overcurrent	■	■	■	–	–	–
50N	Instantaneous earth-fault overcurrent	■	■	–	–	–	–
50BF	Breaker failure	■	■	■	–	■	–
51GN	Zero speed and underspeed dev.	–	■	–	–	–	–
51	Overcurrent-time relay, phase	■	■	–	–	–	–
51N	Overcurrent-time relay, earth	■	■	–	–	–	–
51V	Overcurrent-time relay, voltage controlled	■	■	–	–	–	–
59	Overvoltage	■	■	●	●	–	■
59N	Residual voltage earth-fault protection	■	■	–	–	–	–
59GN	Stator earth-fault protection	■	■	–	–	–	–
64	100 % Stator earth-fault protection (20 Hz)	–	●	–	–	–	–
64R	Rotor earth fault	■	■	–	–	–	–

■ Standard function

● Option

* ANSI/EEE C 37.2: IEEE Standard Electrical Power System Device Function Numbers

Relay Functions

Protection functions	Type	Distance		Pilot wire differential	Line differential		Overcurrent								Differential					
		7SA522	7SA6	7SD600	7SD5	7SD610	7SJ45	7SJ46	7SJ600	7SJ602	7SJ61	7SJ62	7SJ63	7SJ64	7VH60	7UT612	7UT613	7UT63	7SS60	7SS52
ANSI No.*	Description																	–		
67	Directional overcurrent	–	–	–	–	–	–	–	–	–	–	■	■	■	–	–	–	–	–	–
67N	Directional earth-fault overcurrent	●	●	–	●	–	–	–	–	■ 1)	–	■	■	■	–	–	–	–	–	–
67G	Stator earth-fault directional overcurrent	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
68	Power swing detection	●	●	–	●	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
74TC	Trip circuit supervision	■	■	–	■	■	–	–	■	■	■	■	■	■	–	●	●	●	–	–
78	Out-of-step protection	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
79	Auto-reclosure	●	●	–	●	●	–	–	●	●	●	●	●	●	–	–	–	–	–	–
81	Frequency protection	■	■	–	●	–	–	–	–	–	–	●	●	●	–	–	–	●	–	–
81R	Rate-of-frequency-change protection	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Vector jump supervision	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
85	Carrier interface/remote trip	■	■	●	■	■	–	–	–	–	–	–	–	–	–	–	–	–	–	■
86	Lockout function	■	■	■	■	■	–	–	–	–	■	■	■	■	–	■	■	■	■	–
87G	Differential protection generator	–	–	–	–	–	–	–	–	–	–	–	–	–	–	■	■	■	–	–
87T	Differential protection transformer	–	–	■	●	●	–	–	–	–	–	–	–	–	■	■	■	■	–	–
87BB	Differential protection busbar	–	–	–	–	–	–	–	–	–	–	–	–	–	–	■	■	■	■	■
87M	Differential protection motor	–	–	–	–	–	–	–	–	–	–	–	–	–	–	■	■	■	–	–
87L	Differential protection line	–	–	■	■	■	–	–	–	–	–	–	–	–	–	■	■	■	–	–
87N	Restricted earth-fault protection	–	–	–	–	–	–	–	–	–	■	■	■	■	■	●	●	●	–	–

■ Standard function
● Option
* ANSI/EEE C 37.2: IEEE Standard Electrical Power System Device Function Numbers
1) only sensitive directional earth-fault overcurrent (67Ns)

Protection functions	Type	Generator and motor protection 7UM61	Generator and motor protection 7UM62	Breaker management 7VK61	Synchronizing 7VE6	Breaker failure 7SV600	Voltage, frequency 7RW600
ANSI No.*	Description				–		
67	Directional overcurrent	■	■	–	–	–	–
67N	Directional earth-fault overcurrent	■	■	–	–	–	–
67G	Stator earth-fault directional overcurrent	■	■	–	–	–	–
68	Power swing detection	–	●	–	–	–	–
74TC	Trip circuit supervision	■	■	■	–	–	–
78	Out-of-step protection	–	■	–	–	–	–
79	Auto-reclosure	–	–	■	–	–	–
81	Frequency protection	■	■	–	●	–	■
81R	Rate-of-frequency-change protection	●	●	–	●	–	●
	Vector jump supervision	●	●	–	●	–	–
85	Carrier interface/remote trip	–	–	–	–	–	–
86	Lockout function	■	■	■	●	–	–
87G	Differential protection generator	–	■	–	–	–	–
87T	Differential protection transformer	–	■	–	–	–	–
87BB	Differential protection busbar	–	–	–	–	–	–
87M	Differential protection motor	–	■	–	–	–	–
87L	Differential protection line	–	–	–	–	–	–
87N	Restricted earth-fault protection	–	●	–	–	–	–

■ Standard function
● Option
* ANSI/EEE C 37.2: IEEE Standard Electrical Power System Device Function Numbers

1

Overview

2

Overview

Description

Simplicity in a complex world
Quite simply – SIPROTEC 4

Face the future with confidence and innovative solutions.

SIPROTEC 4 is a flexible and powerful solution for protecting your power system.

Ergonomic key path and graphic display ensure reliable operation. The powerful software tool DIGSI 4 assists the engineer in comprehensive relay management and fault analysis. Only one tool is required for all SIPROTEC relays.

SIPROTEC 4 offers much more:

- Function mix of protection, control and measurement
- Choice of open communication standards like IEC 60870-5-103 and IEC 61850 protocol, DNP 3, MODBUS and PROFIBUS
- Communication modules also for retrofitting

Siemens actively supported international standard IEC 61850 and is the first manufacturer to offer protection relays and substation control systems with an IEC 61850-compliant communication protocol.

A flexibility that is a pleasure to use.
As pioneers in numerical protection and substation control, we invite you to take advantage of SIPROTEC 4.

LSP2296-afp.tif

Relay Families

Typical Protection Schemes

Protection Coordination

2

Relay Families

Introduction

Siemens is one of the world's leading suppliers of protection equipment for power systems.

Thousands of our relays ensure first-class performance in transmission and distribution networks on all voltage levels, all over the world, in countries of tropical heat or arctic frost.

For many years, Siemens has also significantly influenced the development of protection technology.

- In 1976, the first minicomputer (process computer)-based protection system was commissioned: A total of 10 systems for 110/20 kV substations was supplied and is still operating satisfactorily today.
- Since 1985, we have been the first to manufacture a range of fully numerical relays with standardized communication interfaces.
  Today, Siemens offers a complete range of protection relays for all applications including numerical busbar and machine protection.
  To date, more than 450,000 numerical protection relays from Siemens are providing successful service, as stand-alone units in traditional systems or as components of combined substation protection and substation control.
  Meanwhile, the latest SIPROTEC 4 series has established itself right across the market, incorporating many years of operational experience with thousands of relays, together with users' requirements.

Fig. 2/1

LSP2257-afp.tif

SIPROTEC 4 family

LSP2256-afp.tif

SIPROTEC '600 series

SIP053-afp.eps

SIPROTEC easy series

State-of-the-art technology

Mechanical and solid-state (static) relays have been almost completely phased out of our production because numerical relays are now preferred by the users due to their decisive advantages:

- Compact design and lower costs due to integration of many functions into one relay
- High availability even with less maintenance due to integral self-monitoring
- No drift (aging) of measuring characteristics due to fully numerical processing
- High measuring accuracy due to digital filtering and optimized measuring algorithms
- Many integrated add-on functions, for example, for load-monitoring, event/fault recording and thermal monitoring
- Local operation keypad and display designed to modern ergonomic criteria
- Easy and reliable read-out of information via serial interfaces with a PC, locally or remotely with DIGSI (one tool for all relays)
- Possibility to communicate with higher-level control systems using standardized protocols according to IEC 61850 via Ethernet communication

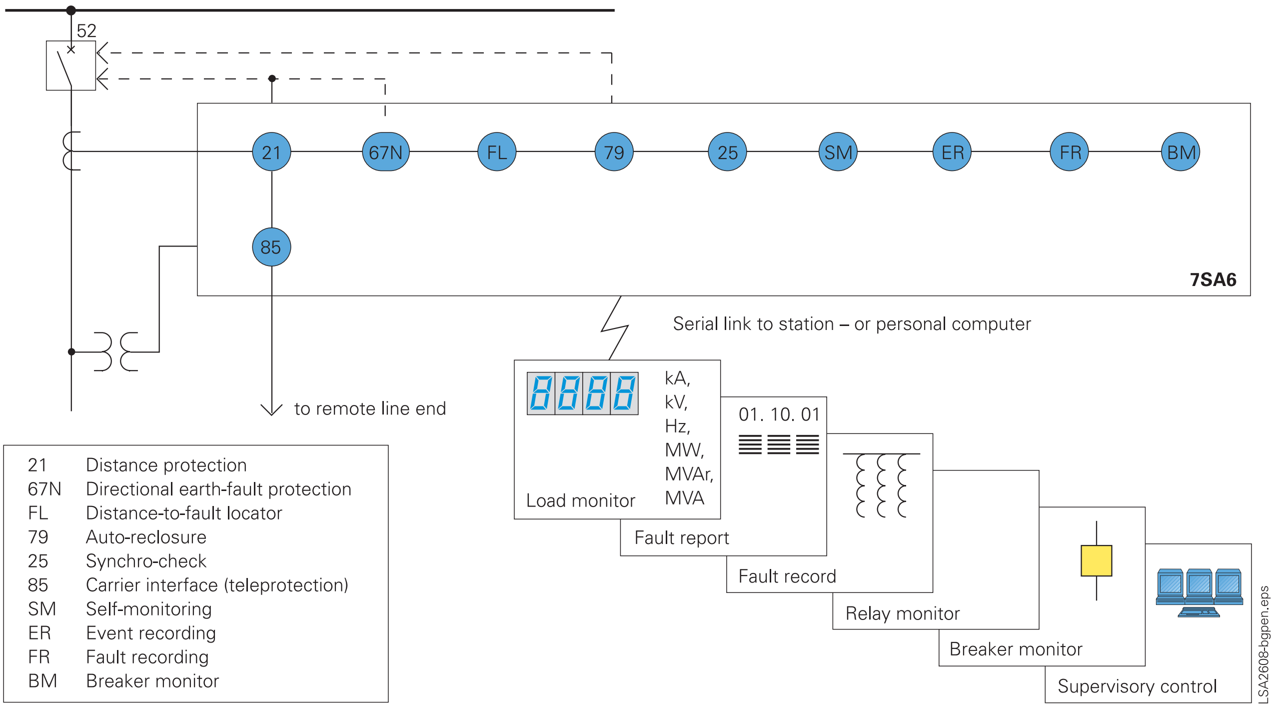


Fig. 2/2
Numerical relays, increased information availability

Modern protection management

All the functions, for example, of a line protection scheme can be incorporated in one unit:

- Distance protection with associated add-on and monitoring functions
- Universal teleprotection interface by binary input/contacts or serial interface
- Auto-reclosure and synchronism check

Protection-related information can be called up on-line or off-line, such as:

- Distance to fault
- Fault currents and fault voltages
- Relay operation data (fault detector pickup, operating times etc.)
- Set values
- Line load data (kV, A, MW, kVAr)

To fulfill vital protection redundancy requirements, only those functions which are interdependent and directly associated with each other are integrated in the same unit. For back-up protection, one or more additional units should be provided.

All relays can stand fully alone. Thus, the traditional protection concept of separate main and backup protection as well as the external connection to the switchyard remain unchanged.

"One feeder, one relay" concept

Analog protection schemes have been engineered and assembled from individual relays. Interwiring between these relays and scheme testing has been carried out manually in the workshop.

Data sharing now allows for the integration of several protection and protection-related tasks into one single numerical relay. Only a few external devices may be required for completion of the total scheme. This has significantly lowered the costs of engineering, assembly, panel wiring, testing and commissioning. Scheme failure probability has also been lowered.

Engineering has moved from schematic diagrams towards a parameter definition procedure. A powerful user-definable logic integrated in SIPROTEC 4 allows flexible customized design for protection, control and measurement.

Measuring included

For many applications, the accuracy of the protection current transformer is sufficient for operational measuring. The additional measuring c.t. was required to protect the measuring instruments under short-circuit conditions. Due to the low thermal withstand capability of the measuring instruments, they could not be connected to the protection c.t.. Consequently, additional measuring core c.t.s and measuring instruments are now only necessary where high accuracy is required, e.g. for revenue metering.

2

Relay Families

On-line remote data exchange

A powerful serial data link provides for interrogation of digitized measured values and other information stored in the protection units, for printout and further processing at the substation or system control level.
In the opposite direction, setting groups may be altered or test routines initiated from a remote control center.

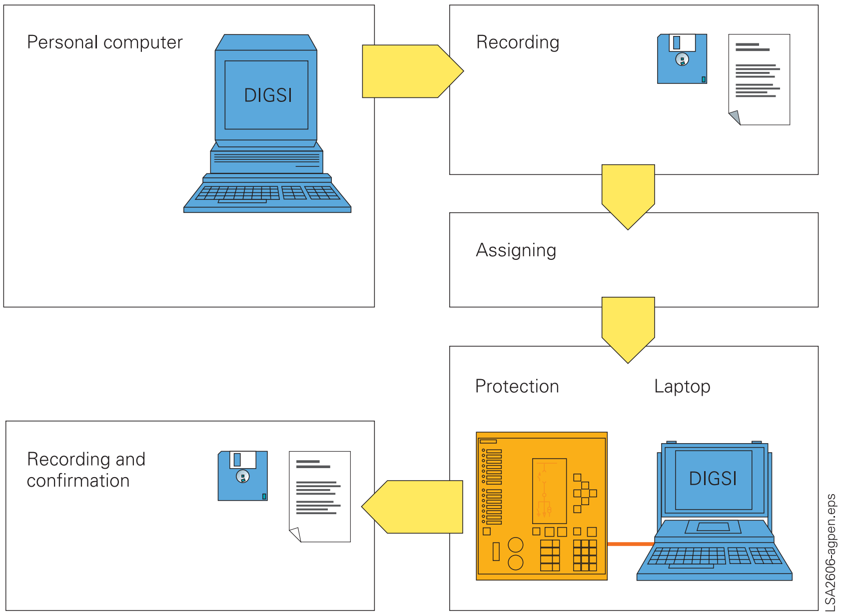


Fig. 2/3
PC-aided setting procedure

For greater distances, especially in outdoor switchyards, fiber-optic cables are preferably used. This technique has the advantage that it is totally unaffected by electromagnetic interference.

Off-line dialog with numerical relays

A simple built-in operator panel which requires no special software knowledge or codeword tables is used for parameter input and readout.

This allows operator dialog with the protection relay. Answers appear largely in plain-text on the display of the operator panel. The dialog is divided into three main phases:

- Input, alternation and readout of settings
- Testing the functions of the protection unit and
- Readout of relay operation data for the last system faults.

Modern power system protection management

A notebook PC may be used for upgraded protection management.

The MS Windows-compatible relay operation program DIGSI is available for entering and readout of setpoints and archiving of protection data for all SIPROTEC relays. For the whole relay family only one PC-software is required. Relay updates are offered now on Internet at http://www.siprotec.com.

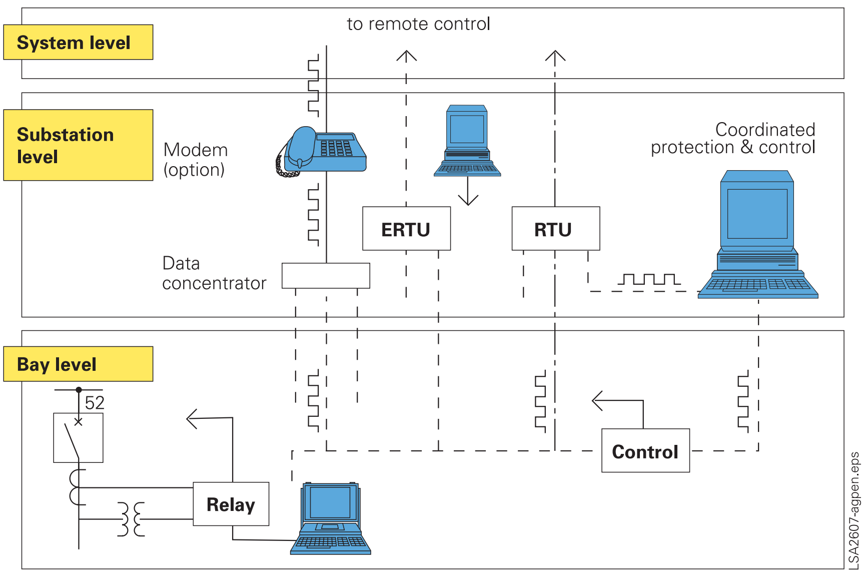


Fig. 2/4 Communication options

The relays may be set in 2 steps. First, all relay settings are prepared in the office with the aid of a local PC and stored on a file. On site, the settings can then be downloaded from a PC into the relay. The relay confirms the settings and thus provides an unquestionable record.

Vice versa, after a system fault, the relay memory can be uploaded to a PC, and comprehensive fault analysis can then take place in the engineer's office if required.

Alternatively, the total relay dialog can be guided from any remote location via a modem-telephone connection (Fig. 2/4) or via the utility network.

Relay data management

Distribution type relays have some important 20-30 setpoints. If we consider a power system with about 500 relays, then the number adds up to 10,000 settings. This requires considerable expenditure in setting the relays and filing retrieval setpoints.

A personal computer-aided human-machine dialog and archiving program, e.g. DIGSI, assists the relay engineer in data filing and retrieval.

Corrective rather than preventive maintenance

Numerical relays monitor their own hardware and software. Exhaustive self-monitoring and failure diagnostic routines are not restricted to the protection relay itself, but are methodically carried through from current transformer circuits to tripping relay coils.

Equipment failures and faults in the c.t. circuits are immediately reported and the protection relay is blocked.

Thus, the service personnel is now able to correct the failure upon occurrence, resulting in a significantly upgraded availability of the protection system.

Adaptive relaying

Numerical relays now offer reliable, convenient and comprehensive matching to changing conditions. Matching may be initiated either by the relay's own intelligence or from other systems via contacts or serial telegrams. Modern numerical relays contain a number of parameter sets that can be pretested during commissioning of the scheme (Fig. 2/6). One set is normally operative. Transfer to the other sets can be controlled via binary inputs or serial data link.

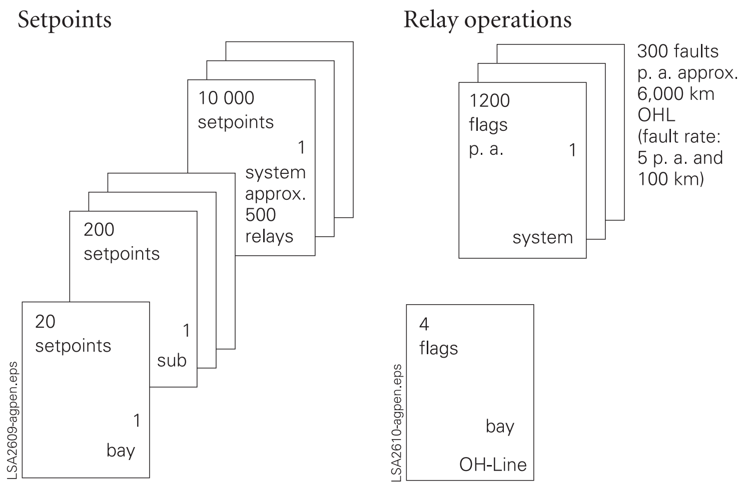


Fig. 2/5
System-wide setting and relay operation library

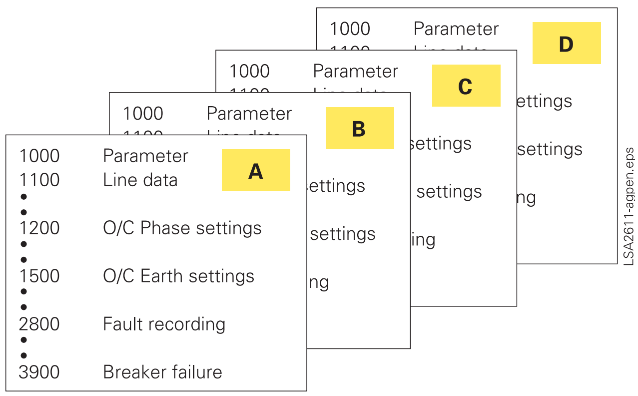


Fig. 2/6
Alternate parameter groups

There is a number of applications for which multiple setting groups can upgrade the scheme performance, e.g.

- For use as a voltage-dependent control of overcurrent-time relay pickup values to overcome alternator fault current decrement to below normal load current when the automatic voltage regulator (AVR) is not in automatic operation.
- For maintaining short operation times with lower fault currents, e.g. automatic change of settings if one supply transformer is taken out of service.
- For "switch-onto-fault" protection to provide shorter time settings when energizing a circuit after maintenance. The normal settings can be restored automatically after a time delay.
- For auto-reclosure programs, i.e. instantaneous operation for first trip and delayed operation after unsuccessful reclosure.
- For cold load pickup problems where high starting currents may cause relay operation.
- For "ring open" or "ring closed" operation.

Relay Families

Implemented functions

SIPROTEC relays are available with a variety of protective functions. See description of the relay families (page 2/9 and following).

Fig. 2/7 left
Switchgear with numerical relay (7SJ62) and traditional control

Fig. 2/7 right
Switchgear with combined protection and control relay (7SJ63)

The high processing power of modern numerical units allows further integration of non-protective add-on functions.

The question as to whether separate or combined relays should be used for protection and control cannot be uniformly answered. In transmission-type substations, separation into independent hardware units is still preferred, whereas on the distribution level a trend towards higher function integration can be observed. Here, combined feeder/line relays for protection, monitoring and control are on the march (Fig. 2/7).

Relays with protection functions only and relays with combined protection and control functions are being offered. The SIPROTEC 3 relays offer protection functions while SIPROTEC 4 relays have combined protection and control functions. SIPROTEC 4 relays support the “one relay one feeder” concept and thus contribute to a considerable reduction in space and wiring.

With the well-proven SIPROTEC 4 family, Siemens supports both stand-alone and combined solutions on the basis of a single hardware and software platform. The user can decide within wide limits on the configuration of the control and protection functions in the line, without influencing the reliability of the protection functions (Fig. 2/8).

The following solutions are available within one relay family:

- Separate control and protection relays
- Feeder protection and remote control of the line circuit-breaker via the serial communication link
- Combined relays for protection, monitoring and control

Mixed use of the different relay types is possible on account of the uniform operation and communication procedures.

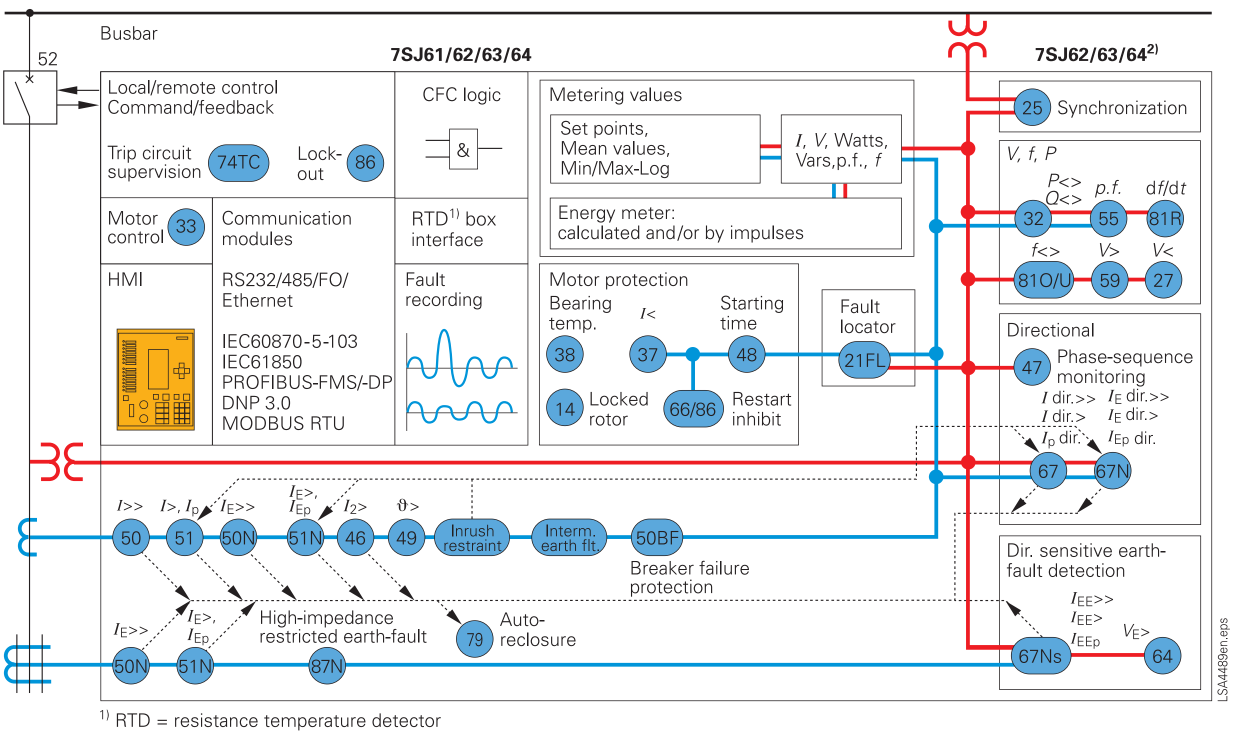


Fig. 2/8
SIPROTEC 4 relays 7SJ61/62/63, 64 implemented functions

1) RTD = resistance temperature detector

2) VT connection for 7SJ62/63/64 only

Siemens offers the user a uniform technique covering the whole range of protection applications. This includes a uniform operator concept, uniform housing technology, common communication protocols and a uniform technology.

This offers a number of advantages for the user:

- Reduced engineering and testing efforts due to well-suited functions
- Reduced training due to uniform operation and setting for all relays
- Uniform data management due to a common operator program

Our 3 product families have a common basis and with their characteristic features are optimized for your main area of application.

The SIPROTEC 4 family:

A great variety of units ranging from overcurrent-time protection for medium-voltage applications to distance and differential protection for extra-high-voltage applications. All the units have control functions (partly with graphic display) and offer a great variety of communications possibilities. They have a large number of integrated protection functions, from which the user can easily select those required for his specific case of application.

The SIPROTEC '600 series:

Cost-effective units especially for use in industry or power supply utilities, where the entire scope of functions of the SIPROTEC 4 family is not required.

The SIPROTEC 3 family:

The well-proven range of numerical protection units for all applications concerning medium voltage up to extra-high voltage.

All these families or series of devices can be used with our DIGSI operating program.

The SIPROTEC easy series:

For simple applications, the relay series SIPROTEC easy completes the SIPROTEC family.

SIPROTEC easy means:

- High quality at a favorable price
- Simple setting via dip switches, no PC program required
- Easy mounting due to compact housing
- Current transformer (CT) powered or auxiliary voltage supplied version available
- Condensation-proof version available

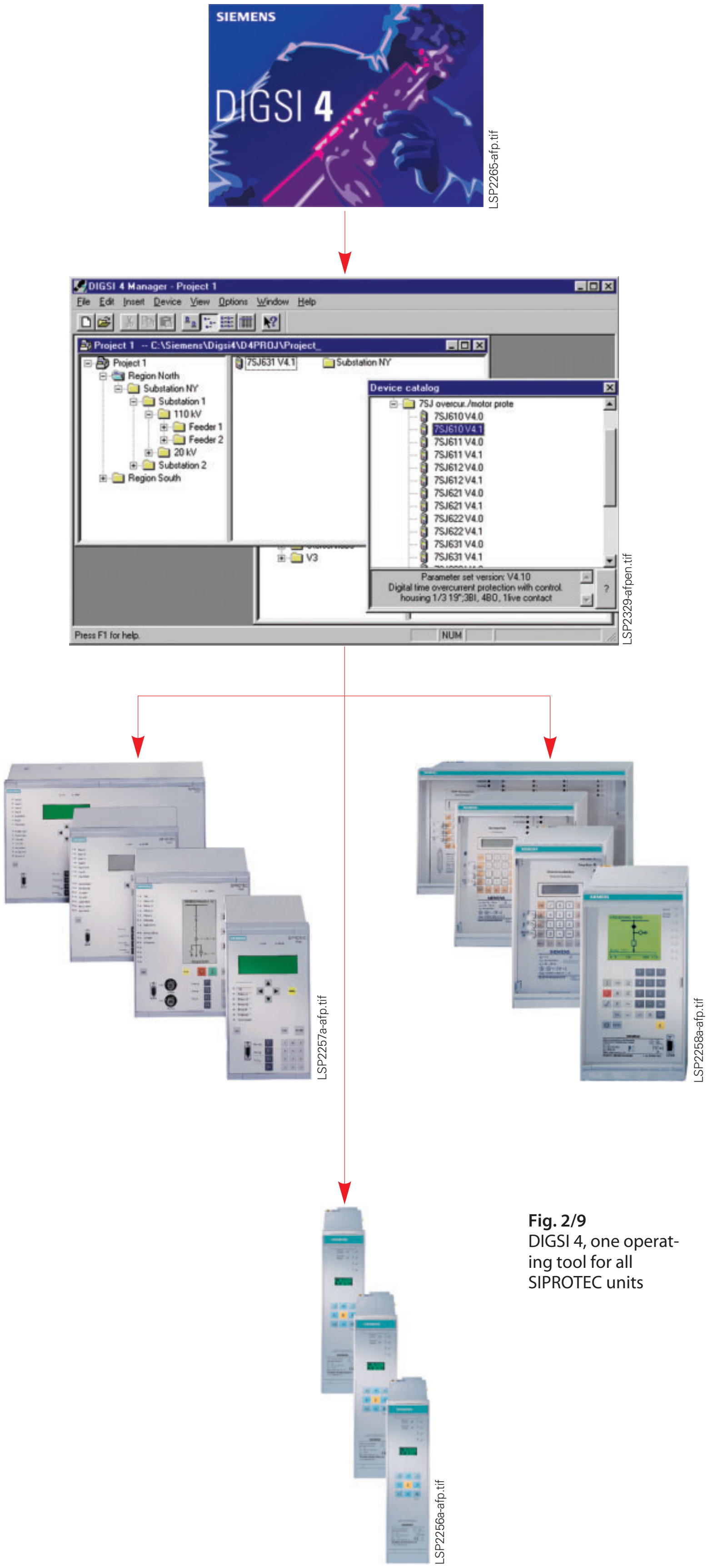


Fig. 2/9
DIGSI 4, one operating tool for all SIPROTEC units

Relay Families

Fig. 2/10 1/1 of 19″

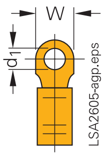


Fig. 2/11 1/2 of 19″

Fig. 2/12 1/3 of 19″

Fig. 2/13 SIPROTEC 4 combined protection, control and monitoring relay 7SJ63 with detached operator panel

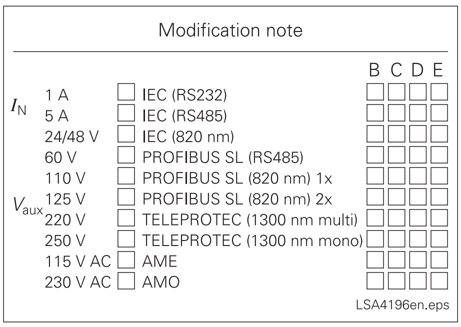


Fig. 2/14

SIPROTEC 4 relays

SIPROTEC 4 relays are available in 1/3 to 1/1 of 19″ wide housings with a standard height of 243 mm. Their size is compatible with that of other relay families. Therefore, compatible exchange is always possible.
All wires (cables) are connected at the rear side of the relay with or without ring cable lugs. A special relay version with a detached cable-connected operator panel (Fig. 2/13) is also available. It allows, for example, the installation of the relay itself in the low-voltage compartment and of the operator panel separately in the door of the switchgear.

Terminals

Standard relay version with screw-type terminals

Current terminals

Connection	W_{max} = 12 mm
Ring cable lugs	d_1 = 5 mm
Wire size	2.7 - 4 mm^2 (AWG 13 - 11)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	2.7 - 4 mm^2 (AWG 13 - 11)

Voltage terminals

Connection	W_{max} = 10 mm
Ring cable lugs	d_1 = 4 mm
Wire size	1.0 - 2.6 mm^2 (AWG 17 - 13)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	0.5 - 2.5 mm^2 (AWG 20 - 13)

Some relays are alternatively available with plug-in voltage terminals

Current terminals

Screw type (see standard version)

Voltage terminals

2-pin or 3-pin connectors	
Wire size	0.5 - 1.0 mm^2 0.75 - 1.5 mm^2 1.0 - 2.5 mm^2

Adaptation to substation environment

Not only can the software of SIPROTEC units be flexibly adapted to substation conditions; the units themselves can be adapted to the secondary CT rated current I_N (1 A or 5 A) or the auxiliary voltage V_{aux} via internal settable jumpers. To achieve a correct indication of the secondary measured values on the display of the relay, you have to reset the "CT rated current" parameter in DIGSI. You should also mark the modifications you have made on the "Modification note" plate (Fig. 2/14).

2

Local operation

All operator actions can be executed and information displayed via an integrated user interface. Two alternatives for this interface are available.

On the backlit LCD display, process and device information can be displayed as text.

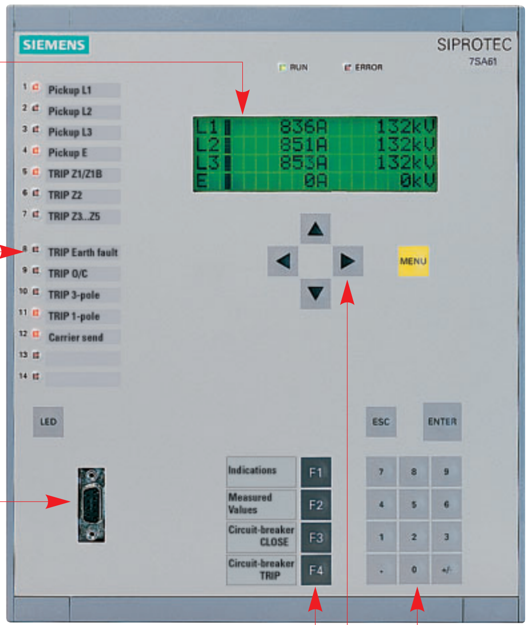
Freely assignable LEDs are used to display process or device information. The LEDs can be labelled according to user requirements. An LED reset key resets the LEDs and can be used for LED testing.

RS232 operator interface (for DIGSI)

4 configurable function keys permit the user to execute frequently used actions simply and fast.

Keys for navigation

Numerical keys



LSP2284-afpen.eps

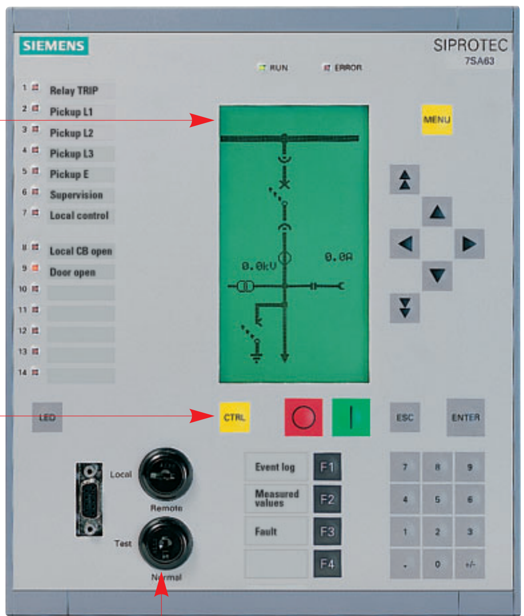
Fig. 2/15

Additional features of the interface with graphic display.

Process and relay information can be displayed on the large illuminated LC display either graphically in the form of a mimic diagram or as text in various lists.

The keys mainly used for control of the switchgear are located on the “control axis” directly below the display.

Two key-operated switches ensure rapid and reliable changeover between “Local” and “Remote” control and between “interlocked” and “non-interlocked” operation.



LSP2283-afpen.eps

Fig. 2/16

Relay Families

SIPROTEC 4 relays

Apart from the relay-specific protection functions, the SIPROTEC 4 units have a multitude of additional functions which

- Provide you with information for the evaluation of faults
- Facilitate adaption to your specific application
- Facilitate monitoring and control of your installation

Operational measured values

The large scope of measured and limit values permits improved power system management as well as simplified commissioning.

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available depending on the relay type

- Currents I_{L1}, I_{L2}, I_{L3}, I_N, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1-L2}, V_{L2-L3}, V_{L3-L1}
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, $3V_0$
- Power Watts, Vars, VA/P, Q, S
- Power factor p.f. (cos φ)
- Frequency
- Energy ± kWh ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values (some types)

For internal metering, the unit can calculate energy metered values from the measured current and voltage values. If an external meter with a metering pulse output is available, some SIPROTEC 4 types can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Measuring transducer (some types)

- Knee characteristic
  For measuring transducers it sometimes makes sense to extend a small range of the input value, e.g. for the frequency that is only relevant in the range 45 to 55, 55 to 65 Hz. This can be achieved by using a knee characteristic.
- Live-zero monitoring
  4 - 20 mA circuits are monitored for open-circuit detection.

Operational indications and fault indications with time stamp

The SIPROTEC 4 units provide extensive data for fault analysis as well as control. All indications listed below are stored even if the power supply is disconnected.

- Fault event log
  The last eight network faults are stored in the unit. All fault recordings are time-stamped with a resolution of 1 ms.
- Operational indications
  All indications that are not directly associated with a fault (e.g. operating or switching actions) are stored in the status indication buffer. The time resolution is 1 ms.

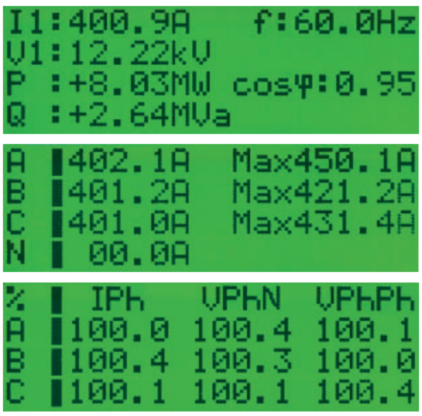


Fig. 2/17
Operational measured values

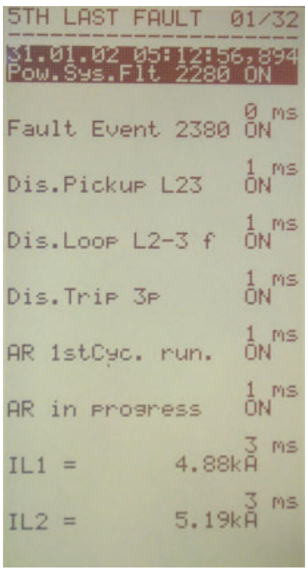


Fig. 2/18
Fault event log

Display editor

A display editor is available to design the display on SIPROTEC 4 units with graphic display. The predefined symbol sets can be expanded to suit the user. The drawing of a single-line diagram is extremely simple. Load monitoring values (analog values) and any texts or symbols can be placed on the display where required.

Four predefined setting groups for adapting relay settings

The settings of the relays can be adapted quickly to suit changing network configurations. The relays include 4 setting groups which can be predefined during commissioning or even changed from remote via a DIGSI 4 modem link. The setting groups can be activated via binary inputs, via DIGSI 4 (local or remote), via the integrated keypad or via the serial substation control interface.

Fault recording up to 5 or more seconds

The sampled values for phase currents, earth (ground) currents, line and zero-sequence currents are recorded in a fault record. The record can be started using a binary input, on pickup or when a trip command occurs. Up to eight fault recordings may be stored. For test purposes, it is possible to start a fault recording via DIGSI 4. If the storage capacity is exceeded, the oldest fault recording in each case is overwritten.

For protection functions with long delay times in generator protection the r.m.s. value recording is available. Storage of relevant calculated variables (V_1, V_E, I_1, I_2, I_{EE}, P, Q, f-fn) takes place at increments of one cycle. The total time is 80 seconds.

Time synchronization

A battery-backed clock is a standard component and can be synchronized via a synchronization signal (DCF77, IRIG B via satellite receiver), binary input, system interface or SCADA (e.g. SICAM). A date and time is assigned to every indication.

Selectable binary inputs and outputs

Binary inputs, outputs and LEDs can be assigned to perform specific functions as defined by the user.

Selectable function keys

Four function keys can be assigned to permit the user to perform frequently recurring actions very quickly and simply.

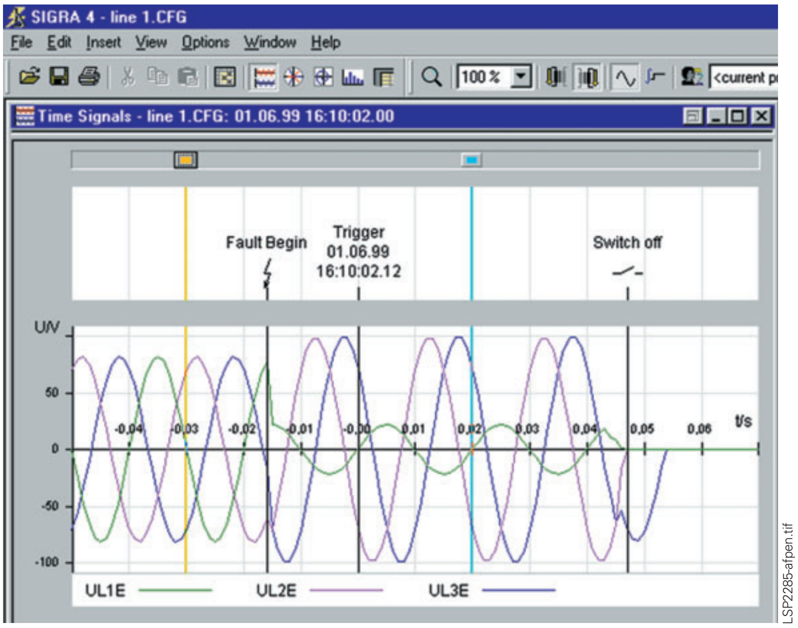


Fig. 2/19
Display and evaluation of a fault record using SIGRA

Typical applications are, for example to display the list of operating indications or to perform automatic functions, such as “Switching of circuit-breaker”.

Continuous self-monitoring

The hardware and software are continuously monitored. If abnormal conditions are detected, the unit signals immediately. In this way, a great degree of safety, reliability and availability is achieved.

Reliable battery monitoring

The battery that is provided is used to backup the clock, the switching statistics, the status and fault indications and the fault recording in the event of a power supply failure. Its function is checked by the processor at regular intervals. If the capacity of the battery is found to be declining, an alarm is generated. Regular replacement is therefore not necessary.

All setting parameters are stored in the Flash-EPROM and are not lost if the power supply or battery fails. The SIPROTEC 4 unit remains fully functional.

Commissioning support

Special attention has been paid to commissioning. All binary inputs and output contacts can be displayed and activated directly. This can significantly simplify the wiring check for the user. Test telegrams to a substation control system can be initiated by the user as well.

2

Relay Families

SIPROTEC 4 relays

CFC: Programming logic

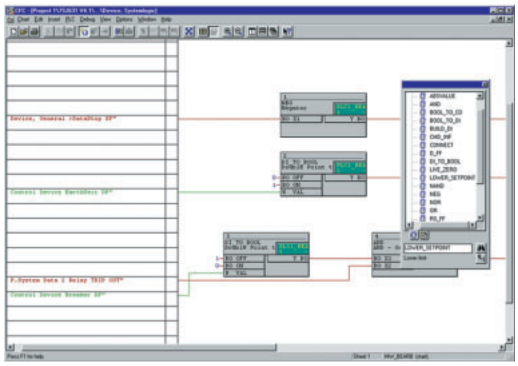
With the help of the CFC graphic tool (Continuous Function Chart) interlocking schemes and switching sequences can be configured simply via drag and drop of logic symbols; no special knowledge of programming is required. Logical elements, such as AND, OR, flip-flops and timer elements are available. The user can also generate user-defined annunciations and logical combinations of internal or external signals.

Communication interfaces

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards.

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.



LSP2273-afpen.tif

Fig. 2/20
CFC logic with module library

Retrofitting: communication modules

It is possible that the relays are supplied directly with two communication modules for the service and substation control interfaces or to retrofit the communication modules at a later stage. The modules are mounted on the rear side of the relay. As standard, the time synchronization interface is always supplied.
The communication modules are available for the entire SIPROTEC 4 relay range. Depending on the relay type the following protocols are available: IEC 60870-5-103, PROFIBUS-FMS/DP, MODBUS RTU, DNP 3.0, Ethernet with IEC 61850 (for some relays). No external protocol converter is required.

The following interfaces can be applied for:

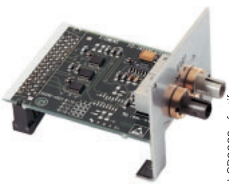
- *Service interface (optional)*
  Several protection relays can be centrally operated with DIGSI 4, e.g. via a star coupler or RS485 bus. On connection of a modem, remote control is possible. This provides advantages in fault clearance, in particular in unmanned power stations. (Alternatively, the external temperature monitoring box can be connected to this interface.)

- *System interface (optional)*
  This is used to carry out communication with a control system and supports, depending on the module connected, a variety of communication protocols and interface designs.

- *Time synchronization interface*
  A synchronization signal (DCF 77, IRIG B via satellite receiver) may be connected to this input, if no time synchronization is executed on the system interface. This offers a high-precision time tagging.

LSP2261-afpen.tif

Fig. 2/21 Protection relay

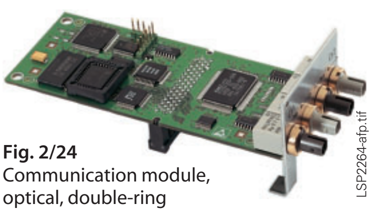


LSP2262-afp.tif

Fig. 2/22
Communication module, optical

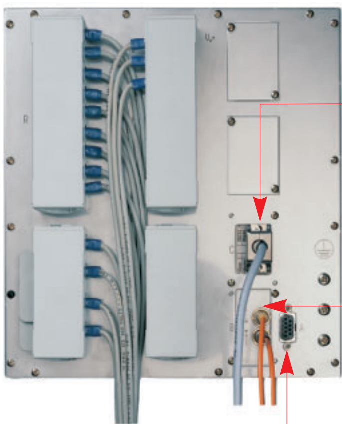
LSP2263-afp.tif

Fig. 2/23
Communication module RS232, RS485



LSP2264-afp.tif

Fig. 2/24
Communication module, optical, double-ring



LSP2274-afp.tif

Fig. 2/25
Rear view with wiring, terminal safety cover and serial interface

With respect to communication, particular emphasis is placed on the requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user can apply these features without any additional programming effort.
- For reliable execution of a command, the relevant signal is first acknowledged in the unit involved. When the command has been enabled and executed, a check-back indication is issued. The actual conditions are checked at every command handling step. Whenever they are not satisfactory, controlled interruption is possible.

Safe bus architecture

- Fiber-optic double ring circuit via Ethernet
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without interruption. If a unit were to fail, there is no effect on the communication with the rest of the system.
- RS485 bus
  With this data transmission via copper conductors, electromagnetic interference is largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any faults.
- Star structure
  The relays are connected with a fiber-optic cable with a star structure to the control unit. The failure of one relay/connection does not affect the others.

Depending on the relay type, the following protocols are available:

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

Note:

For further details of communication features, please refer to Part 4.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for efficient communication between the protection relays and the central unit. Siemens-specific extensions which are published, can be used.

PROFIBUS-DP

For connection to a SIMATIC PLC, the PROFIBUS-DP protocol is recommended. With the PROFIBUS-DP the protection relay can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and control commands.

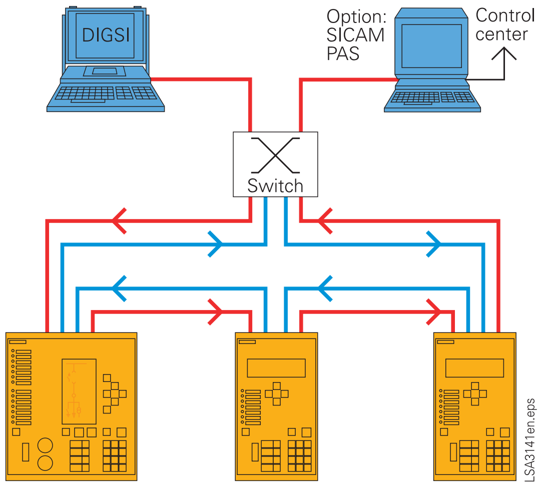


Fig. 2/26
Bus structure for station bus with Ethernet and IEC 61850

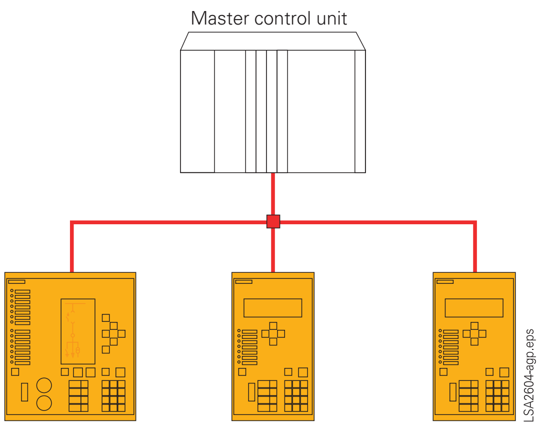


Fig. 2/27
PROFIBUS:
Electrical RS485 bus wiring

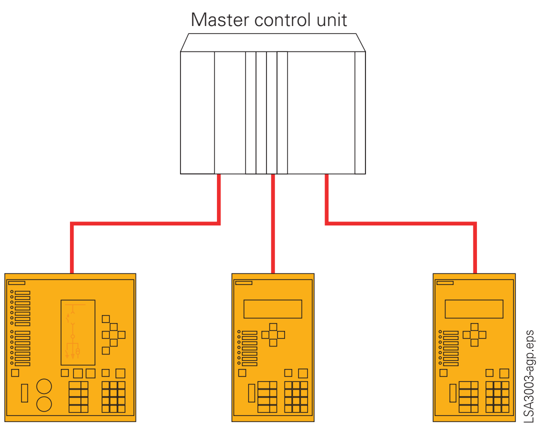


Fig. 2/28
IEC 60870-5-103:
Star structure with fiber-optic cables

2

Relay Families

SIPROTEC 4 relays

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection unit manufacturers.

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions required for operating medium-voltage or high-voltage substations. The main application is reliable control of switching and other processes. The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the relay via binary inputs.

Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a faulty or intermediate breaker position. The switchgear can be controlled via:

- Integrated operator panel
- Binary inputs
- Substation control system
- DIGSI 4.

Automation

With the integrated logic, the user can set specific functions for the automation of the switchgear or substation by means of a graphic interface (CFC). Functions are activated by means of function keys, binary inputs or via the communication interface.

Switching authority

The following hierarchy of switching authority is applicable: “LOCAL”, DIGSI 4 PC program, “REMOTE”. The switching authority is determined according to parameters or by DIGSI 4. If the “LOCAL” mode is selected, only local switching operations are possible. Every switching operation and change of breaker position is stored in the status indication memory with detailed information and time tag.

Command processing

The SIPROTEC 4 protection relays offer all functions required for command processing, including the processing of single and double commands with or without feedback as well as sophisticated monitoring. Control actions using functions such as runtime monitoring and automatic command termination after output check of the external process are also provided by the relays. Typical applications are:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocking
- Operating sequences combining several switching operations such as control of circuit-breakers, isolators (disconnectors) and earthing switches
- Triggering of switching operations, indications or alarms by logical combination of existing information.

Fig. 2/29

LSP2277-afp.tif

Assignment of command feedback

The positions of the circuit-breaker or switching devices are monitored by feedback signals. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication changes as a consequence of switching operation or due to a spontaneous change of state.

Chatter disable

The chatter disable feature evaluates whether the number of status changes of an indication input exceeds a specified figure in a configured period of time. If so, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary control indications can be subjected to a filter time (indication delay) to prevent spurious operation.

Indication filtering and delay

Indications can be filtered or delayed. Filtering serves to suppress brief changes at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the case of indication delay, there is a delay for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Data transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test mode

During commissioning, a test mode can be selected; all indications then have a test mode suffix for transmission to the control system.

SIPROTEC '600 relays

SIPROTEC '600 relays are available in 1/6 of 19" wide housings with a standard height of 243 mm.

Their size is compatible with that of the SIPROTEC 3 and 4 families. Therefore, mixed installations are always possible. Versions for flush mounting and for surface mounting are available.

All wires (cables) are connected at the rear side of the relay via ring cable lugs.

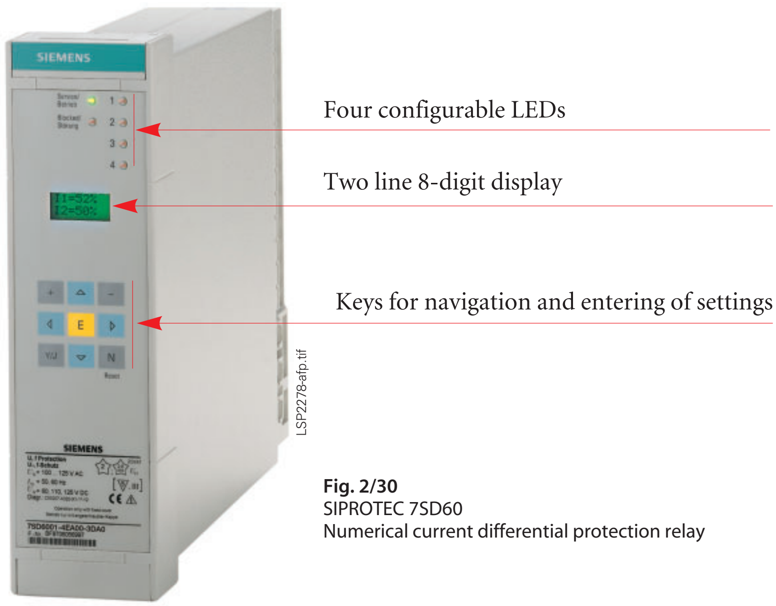
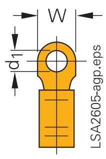


Fig. 2/30
SIPROTEC 7SD60
Numerical current differential protection relay

Terminals
Standard relay version with screw-type terminals



Current terminals:

Connection	W_{max} = 12 mm
Ring cable lugs	d_1 = 5 mm
Wire size	2.7 - 4 mm (AWG 13 - 11)

Voltage terminals:

Connection	W_{max} = 10 mm
Ring cable lugs	d_1 = 4 mm
Wire size	1.0 - 2.6 mm (AWG 17 - 13)

Convenient setting

The menu-driven HMI or a PC with DIGSI is used for setting parameters. These parameters are stored in a non-volatile memory so that the settings are retained even if the supply voltage is disconnected.

Fig. 2/31
Rear view of the flush mounting housing

2

Relay Families

SIPROTEC ‘600 relays

Beside the relay-specific protection functions, the SIPROTEC ‘600 series of relays has a number of additional functions for monitoring and fault analysis.

Operational measured values

Two measured values can be displayed simultaneously on the LCD display. More measured values are available for supervision and commissioning purposes depending on the relay type.

Improved measurement technique

The SIPROTEC ‘600 relays operate fully numerically with enhanced algorithms. Due to the numerical processing of measured values, the influence of higher-frequency transient phenomena and transient DC components is largely suppressed.

Continuous self-monitoring

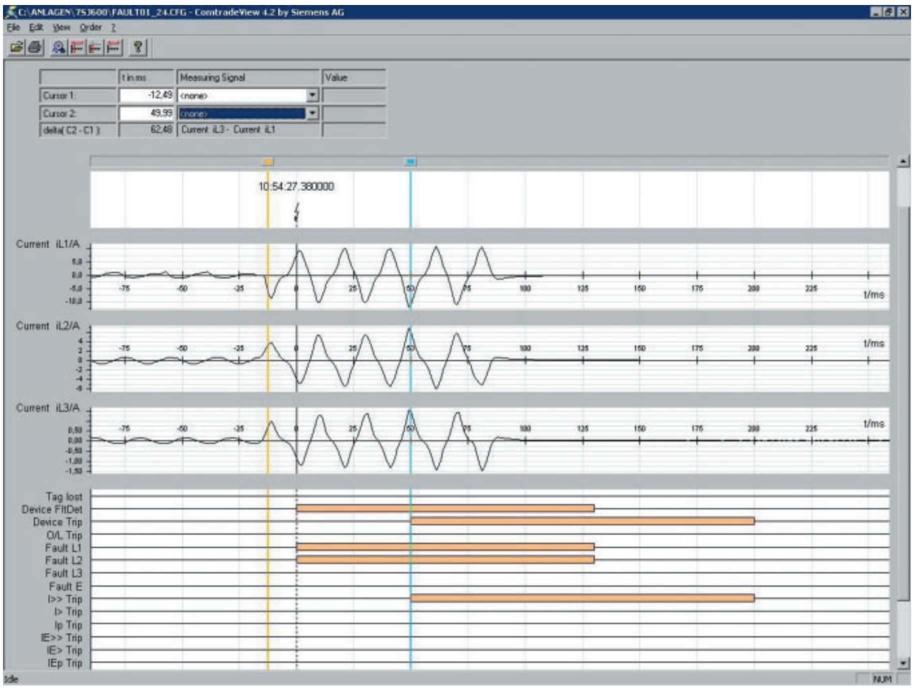
The hardware and software in the SIPROTEC ‘600 relays are continuously self-monitored. This ensures a very high level of availability and reduces the need for routine testing.

Circuit-breaker / Trip contact testing

For testing of the trip circuits, the circuit-breaker can be activated via the command relay. The trip and reclose command contacts can be activated via the keyboard or via the PC interface. This facilitates testing of the trip and close circuits during commissioning without the need for additional test equipment.

Freely assignable inputs and outputs

A number of messages, e.g. blocking of a function via a binary input or the TRIP command (which is assigned to a command contact) is available within the unit.



LSP2369-afpen.tif

Fig. 2/32
Fault record with analog and binary traces

Commonly used messages are preassigned, so that normally there is no need to alter the inputs and outputs.
Nonetheless, provision has been made for “OR” linking by the user of up to 10 messages to a binary input. Up to 20 messages can be simultaneously assigned to a command and alarm relay or to a LED.

Fault analysis

The SIPROTEC ’600 relays supply detailed data for the analysis of faults and for checking of operating conditions

- Fault records (Fig. 2/32)
  The last 8 fault records can always be displayed. If a new fault occurs, the oldest will be overwritten. These records give a detailed description of the fault in the power system and the reaction of the SIPROTEC relay, with 1 ms resolution. Each record is time-stamped and assigned a sequential number to easily associate it with the corresponding waveform capture / oscillographic record. The last oscillographic fault record is retained within the relay even on loss of supply voltage.
- Operational indications
  This log records up to 30 internal events in the relay with 1 ms resolution. These events include setting changes and resets to the relay, binary input activity and other relay internal activities. They are stored in the status indication buffer. There is also an LCD display indicating 2 operational measured values.
- Fault event logs
  The last 8 faults are stored. All fault event logs are time-stamped with a resolution of 1 ms.

Serial data transmission

As standard, the units are fitted with an RS485 interface. This is suitable for connection to a bus and allows connection of up to 32 units via a shielded twisted pair of two-wire serial interface (use of a third conductor for earth is recommended but not required).

This interface may alternatively be used for two different applications:

- Connection to a PC with the DIGSI operating program via an RS485/RS232 converter
- Connection to a substation control system using the IEC 60870-5-103 protocol

A typical application with a connection to a PC is shown in Fig. 2/33. The communication components used for this type of application are described in chapter 4. With the IEC 60870-5-103-mode, only reduced information and the fault records are available. Both, DIGSI operation and IEC-protocol at the same time are only available in the 7SJ602 device.

SIPROTEC 3 relays

Most of the SIPROTEC 3 relays are already discontinued models.

Suitable SIPROTEC 4 relays are available to replace most SIPROTEC 3 relays. SIPROTEC 4 relays should be used in new substations. Assignment for SIPROTEC 4 relays see page 16/26.

Fig. 2/34
SIPROTEC 3 relays

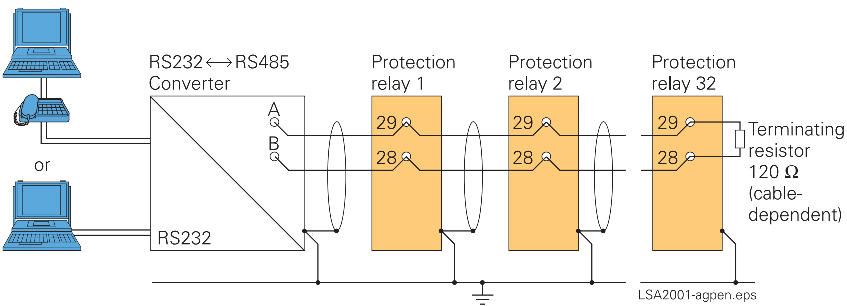


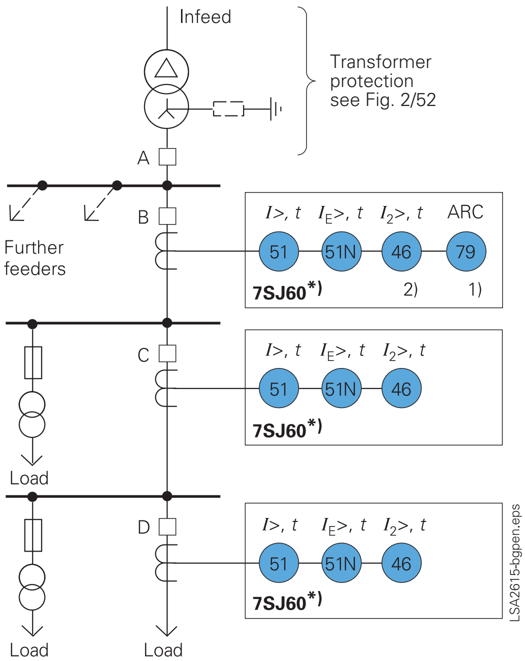
Fig. 2/33
Bus communication via RS485 interface with DIGSI

Note:
For convenient wiring of RS485 bus, use bus cable system 7XV5103 (see part 14 of this catalog)

Typical Protection Schemes

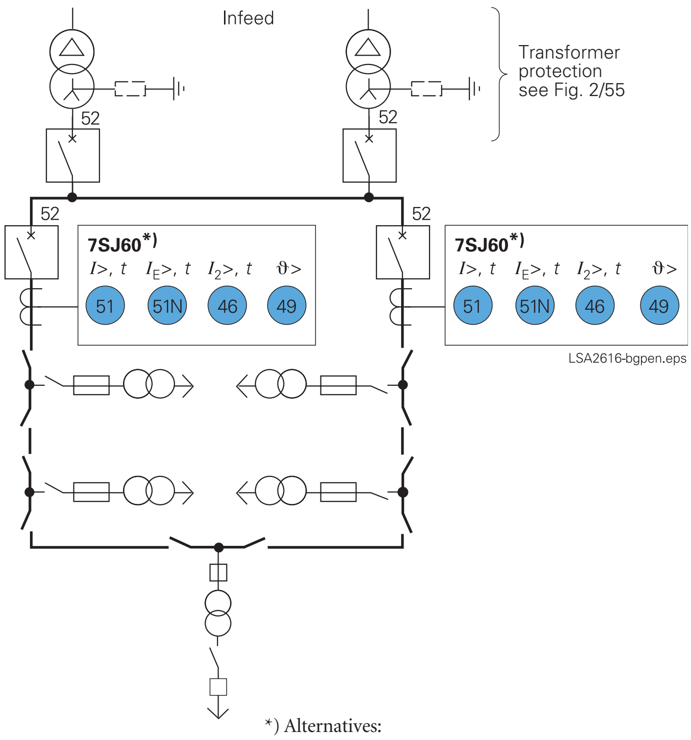
Typical Protection Schemes

Cables and overhead lines



*) Alternatives:
7SJ45/46, 7SJ61

Fig. 2/35



*) Alternatives:
7SJ45/46, 7SJ61

Fig. 2/36

1 Radial systems

Notes:

1) Auto-reclosure 79 only with overhead lines.

2) Negative sequence overcurrent protection 46 as sensitive backup protection against unsymmetrical faults.

General hints:

- The relay at the far end (D) is set with shortest operating time.
  Relays further upstream have to be time-graded against the next downstream relay in steps of about 0.3 seconds.
- Inverse time or definite time can be selected according to the following criteria:

  Definite time:
  Source impedance large compared to the line impedance, i.e. small current variation between near and far end faults

  Inverse time:
  Longer lines, where the fault current is much less at the far end of the line than at the local end.

  Very or extremely inverse time:
  Lines where the line impedance is large compared to the source impedance (high difference for close-in and remote faults) or lines, where coordination with fuses or reclosers is necessary. Steeper characteristics also provide higher stability on service restoration (cold load pickup and transformer inrush currents).

2 Ring-main circuit

General hints:

- Operating time of overcurrent relays to be coordinated with downstream fuses of load transformers. (Preferably very inverse-time characteristic with about 0.2 s grading-time delay)
- Thermal overload protection for the cables (option)
- Negative sequence overcurrent protection 46 as sensitive protection against unsymmetrical faults (option).

3 Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local, via binary input or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker bypassing the internal control function, manual detection using a binary input is implemented.

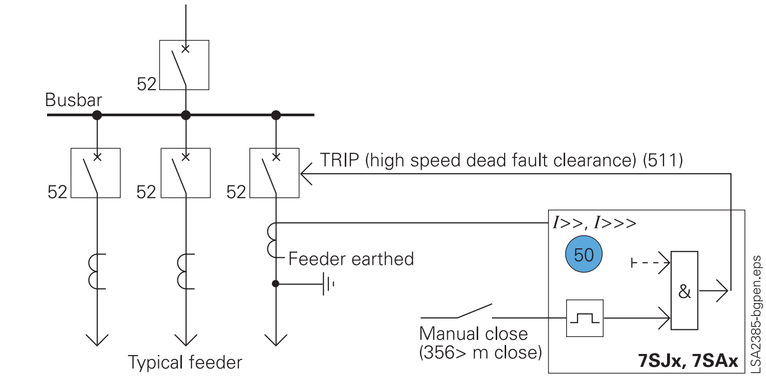


Fig. 2/37

4 Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated time-overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

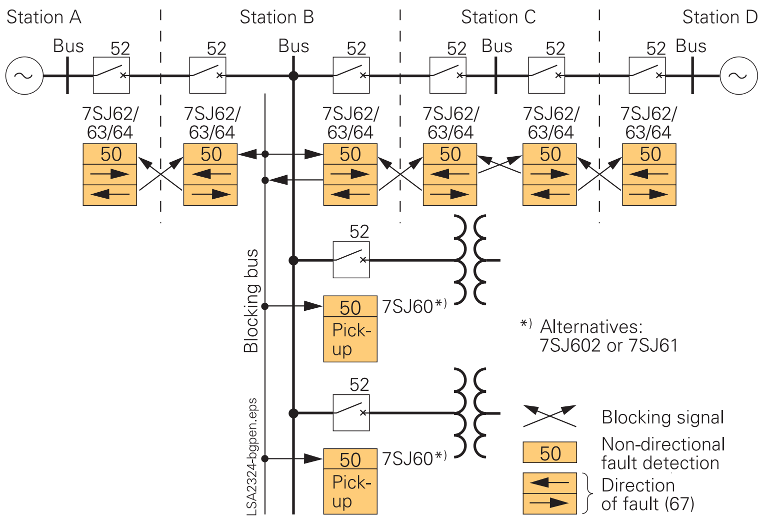


Fig. 2/38

5 Distribution feeder with reclosers

General hints:

- The feeder relay operating characteristics, delay times and auto-reclosure cycles must be carefully coordinated with downstream reclosers, sectionalizers and fuses.
  The 50/50N instantaneous zone is normally set to reach out to the first main feeder sectionalizing point. It has to ensure fast clearing of close-in faults and prevent blowing of fuses in this area ("fuse saving"). Fast auto-reclosure is initiated in this case.
  Further time-delayed tripping and reclosure steps (normally 2 or 3) have to be graded against the recloser.
- The o/c relay should automatically switch over to less sensitive characteristics after long breaker interruption times to enable overriding of subsequent cold load pickup and transformer inrush currents.

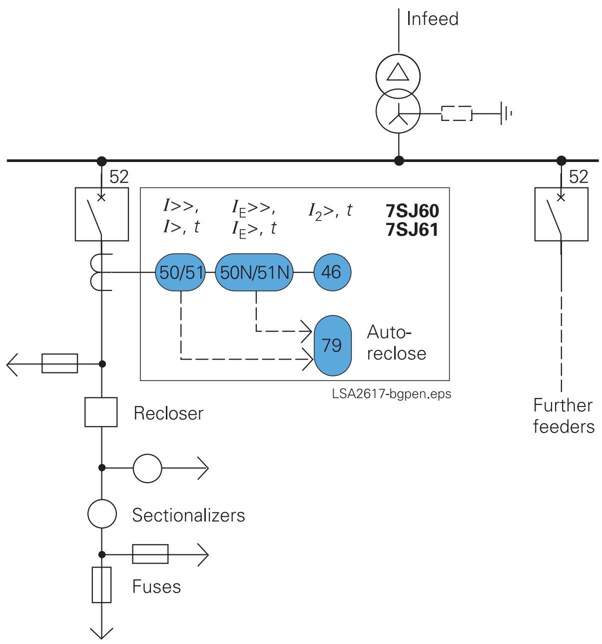


Fig. 2/39

Typical Protection Schemes

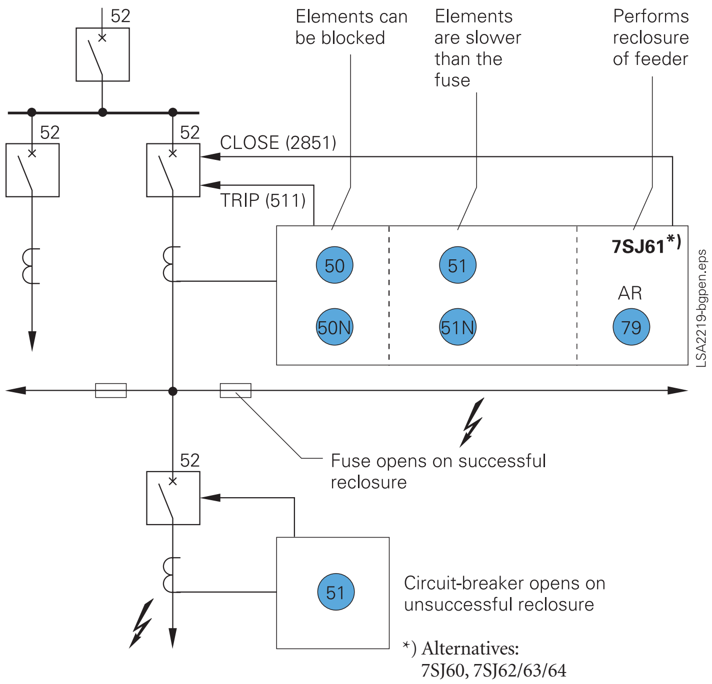


Fig. 2/40

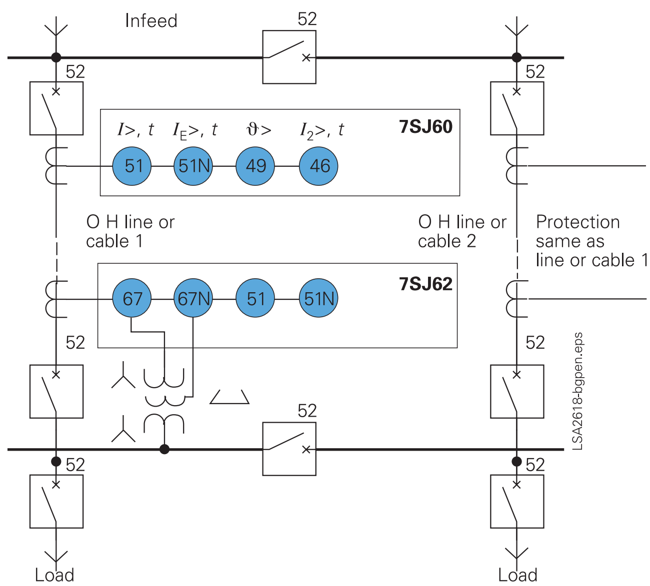


Fig. 2/41

6 3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase auto-reclosing of a feeder which has previously been disconnected by overcurrent protection.

The SIPROTEC 7SJ61 allows up to 9 reclosing shots. The first four dead times can be set individually. Reclosing can be blocked or initiated by a binary input or internally. After the first trip in a reclosing sequence, the high-set instantaneous elements ($I>>>$, $I>>$, $I_E>>$) can be blocked. This is used for fuse saving applications and other similar transient schemes using simple overcurrent relays instead of fuses. The low-set definite-time ($I>$, $I_E>$) and the inverse-time (I_p, I_{Ep}) overcurrent elements remain operative during the entire sequence.

7 Parallel feeder circuit

General hints:

- This circuit is preferably used for the reliable supply of important consumers without significant infeed from the load side.
- The 67/67N directional overcurrent protection trips instantaneously for faults on the protected line. This saves one time-grading interval for the o/c relays at the infeed.
- The 51/51N o/c relay functions must be time-graded against the relays located upstream.

8 Reverse-power monitoring at double infeed

If a busbar is fed from two parallel infeeds and a fault occurs on one of them, only the faulty infeed should be tripped selectively to enable supply to the busbar to continue from the remaining supply. Unidirectional devices that can detect a short-circuit current or energy flow from the busbar towards the incoming unit should be used. Directional time-overcurrent protection is usually set via the load current. However, it cannot clear weak-current faults. The reverse-power protection can be set way lower than the rated power, thus also detecting the reverse-power flow of weak-current faults with fault currents significantly below the load current.

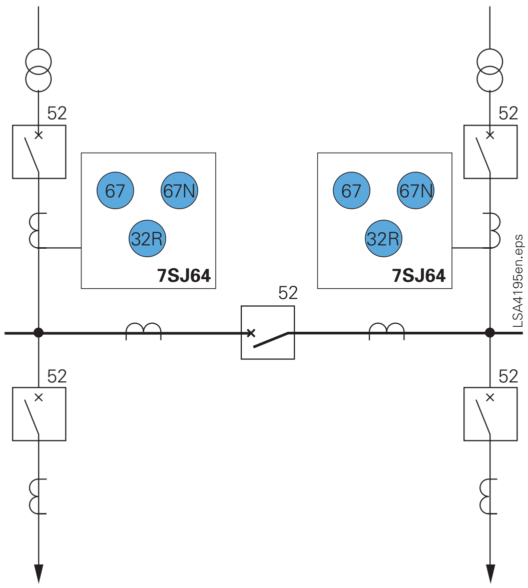


Fig. 2/42

9 Synchronization function

Note:
1) Also available in relays 7SA6, 7SD5, 7SA522, 7VK61.

General hints:
- When two subnetworks must be interconnected, the synchronization function monitors whether the subnetworks are synchronous and can be connected without risk of loosing stability.
- This synchronization function can be applied in conjunction with the auto-reclosure function as well as with the control function CLOSE commands (local/remote).

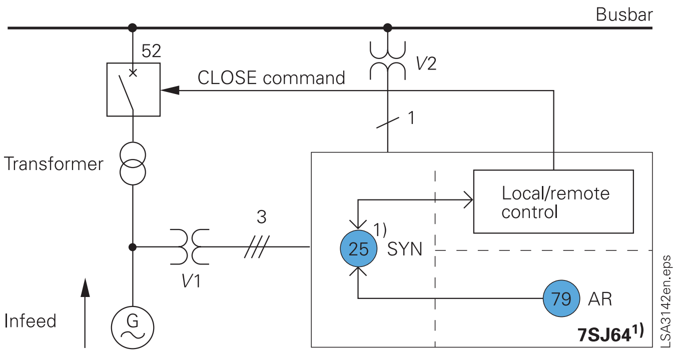


Fig. 2/43

Typical Protection Schemes

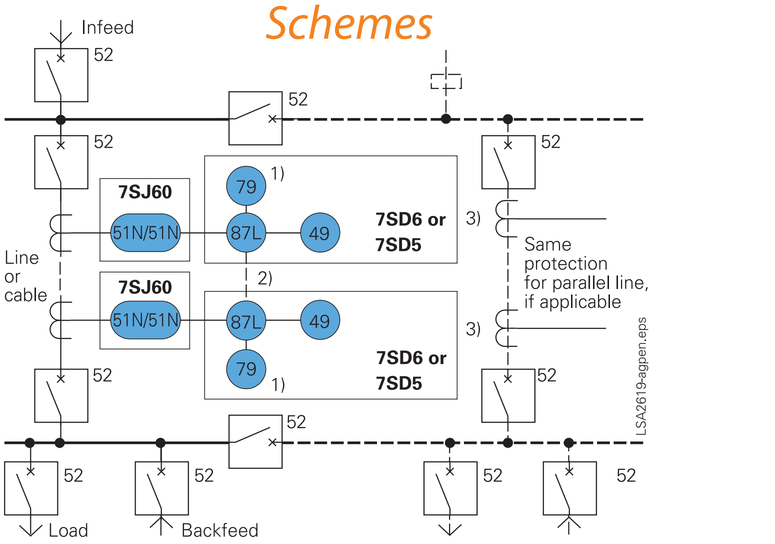


Fig. 2/44

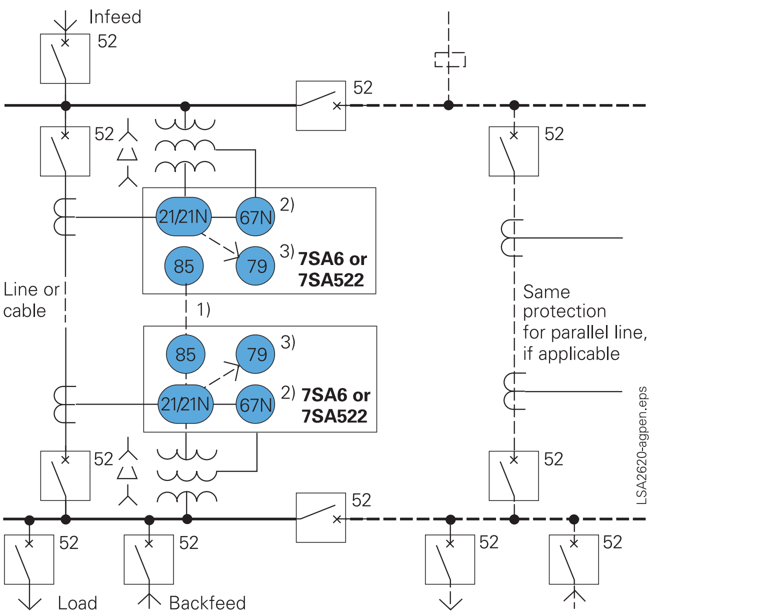


Fig. 2/45

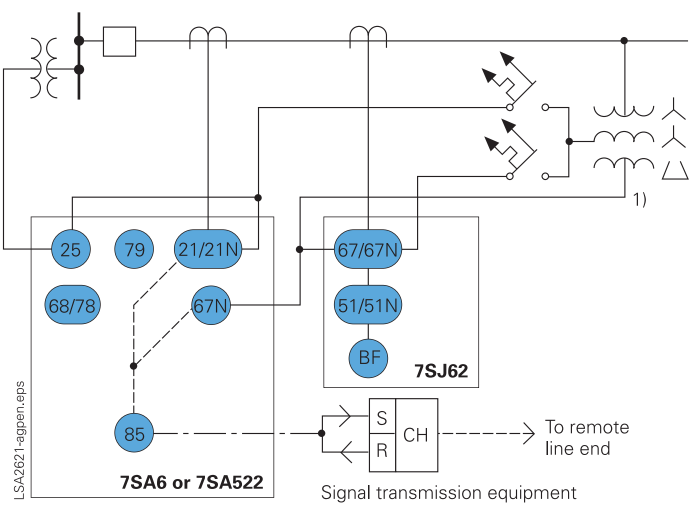


Fig. 2/46

10 Cables or short overhead lines with infeed from both ends

Notes:

1) Auto-reclosure only with overhead lines

2) Differential protection options:

– Type 7SD5 or 7SD610 with direct fiber-optic connection up to about 100 km or via a 64 kbit/s channel (optical fiber, microwave)

– Type 7SD52 or 7SD610 with 7XV5662 (CC-CC) with 2 and 3 pilot-wires up to about 30 km

– Type 7SD600 with 2 pilot-wires up to 12 km 7SD600 is a cost-effective solution where only the function 87L is required (external current summation transformer 4AM4930 delivered separately).

3) Functions 49 and 79 only with 7SD5 and 7SD610 relays.

11 Overhead lines or longer cables with infeed from both ends

Notes:

1) Teleprotection logic 85 for transfer trip or blocking schemes. Signal transmission via pilot wire, power-line carrier, digital network or optical fiber (to be provided separately). The teleprotection supplement is only necessary if fast fault clearance on 100 % line length is required, i.e. second zone tripping (about 0.3 s delay) cannot be accepted for far end faults. For further application hints of teleprotection schemes, please refer to the table on page 2/27.

2) Directional earth-fault protection 67N with inverse-time delay against high-resistance faults

3) Single or multishot auto-reclosure 79 only with overhead lines.

12 Subtransmission line

Note:

1) Connection to open delta winding if available. Relays 7SA6/522 and 7SJ62 can, however, also be set to calculate the zero-sequence voltage internally.

General hints:

- Distance teleprotection is proposed as main, and time-graded directional overcurrent as backup protection.
- The 67N function of 7SA6/522 provides additional high-resistance earth-fault protection. It can be used in parallel with the 21/21N function.
- Recommended teleprotection schemes: PUTT on medium and long lines with phase shift carrier or other secure communication channel POTT on short lines. BLOCKING with On/Off carrier (all line lengths).

Application criteria for frequently used teleprotection schemes

		Permissive underreach transfer trip (PUTT)	Permissive overreach transfer trip (POTT)	Blocking	Unblocking
Preferred application	Signal transmission system	Dependable and secure communication channel: • Power line carrier with frequency shift modulation. HF signal coupled to 2 phases of the protected line, or even better, to a parallel circuit to avoid transmission of the HF signal through the fault location. • Microwave radio, especially digital (PCM) • Fibre-optic cables		Reliable communication channel (only required during external faults) • Power line carrier with amplitude modulation (ON/OFF). The same frequency may be used on all terminals)	Dedicated channel with continuous signal transfer • Power line carrier with frequency shift keying. Continuous signal transmission must be permitted.
	Characteristic of line	Best suited for longer lines - where the underreach zone provides sufficient resistance coverage	• Excellent coverage on short lines in the presence of fault resistance. • Suitable for the protection of multi-terminal lines with intermediate infeed	All line types - preferred practice in the USA	Same as POTT
Advantages		• Simple technique • No coordination of zones and times with the opposite end required. The combination of different relay types therefore presents no problems	• Can be applied without underreaching zone 1 stage (e.g. overcompensated series compensated lines) • Can be applied on extremely short lines (impedance less than minimum relay setting) • Better for parallel lines as mutual coupling is not critical for the overreach zone • Weak infeed terminals are no problem. (Echo and Weak Infeed logic is included)	Same as POTT	Same as POTT but: • If no signal is received (no block and no unblock) then tripping by the overreach zone is released after 20 ms
Drawbacks		• Overlapping of the zone 1 reaches must be ensured. On parallel lines, teed feeders and tapped lines, the influence of zero sequence coupling and intermediate infeeds must be carefully considered to make sure a minimum overlapping of the zone 1 reach is always present. • Not suitable for weak infeed terminals	• Zone reach and signal timing coordination with the remote end is necessary (current reversal)	Same as POTT • Slow tripping - all teleprotection trips must be delayed to wait for the eventual blocking signal • Continuous channel monitoring is not possible	Same as POTT

Typical Protection Schemes

13 Transmission line with reactor

Notes:

1) 51N only applicable with earthed reactor neutral.

2) If phase CTs at the low-voltage reactor side are not available, the high-voltage phase CTs and the CT in the neutral can be connected to a restricted earth-fault protection using one 7VH60 high-impedance relay.

General hints:

- Distance relays are proposed as main 1 and main 2 protection. Duplicated 7SA513 is recommended for series-compensated lines.
- Operating time of the distance relays in the range of 15 to 25 ms depending on the particular fault condition.
  These tripping times are valid for faults in the underreaching distance zone (80 to 85 % of the line length). Remote end faults must be cleared by the superimposed teleprotection scheme.
  Its overall operating time depends on the signal transmission time of the channel, typically 15 to 20 ms for frequency shift audio-tone PLC or microwave channels, and lower than 10 ms for ON/OFF PLC or digital PCM signaling via optical fibers.

Teleprotection schemes based on distance relays therefore have operating times in the order of 25 - 30 ms with digital PCM coded communication. With state-of-the-art two-cycle circuit-breakers, fault clearing times well below 100 ms (4 to 5 cycles) can normally be achieved.

- Dissimilar carrier schemes are recommended for main 1 and main 2 protection, for example PUTT, and POTT or Blocking/Unblocking.
- Both 7SA522 and 7SA6 provide selective single-pole and/or three-pole tripping and auto-reclosure.
  The earth-current directional comparison protection 67N of the 7SA513 relay uses phase selectors based on symmetrical components. Thus, single-pole auto-reclosure can also be executed with high-resistance faults.
  The 67N function of the 7SA6/522 relay can also be used as time-delayed directional over-current backup.
- The 67N functions are provided as high-impedance fault protection. 67N is often used with an additional channel as separate carrier scheme. Use of a common channel with distance protection is only possible if the mode is compatible (e.g. POTT with directional comparison). The 67N may be blocked when function 21/21N picks up. Alternatively, it can be used as time-delayed backup protection.

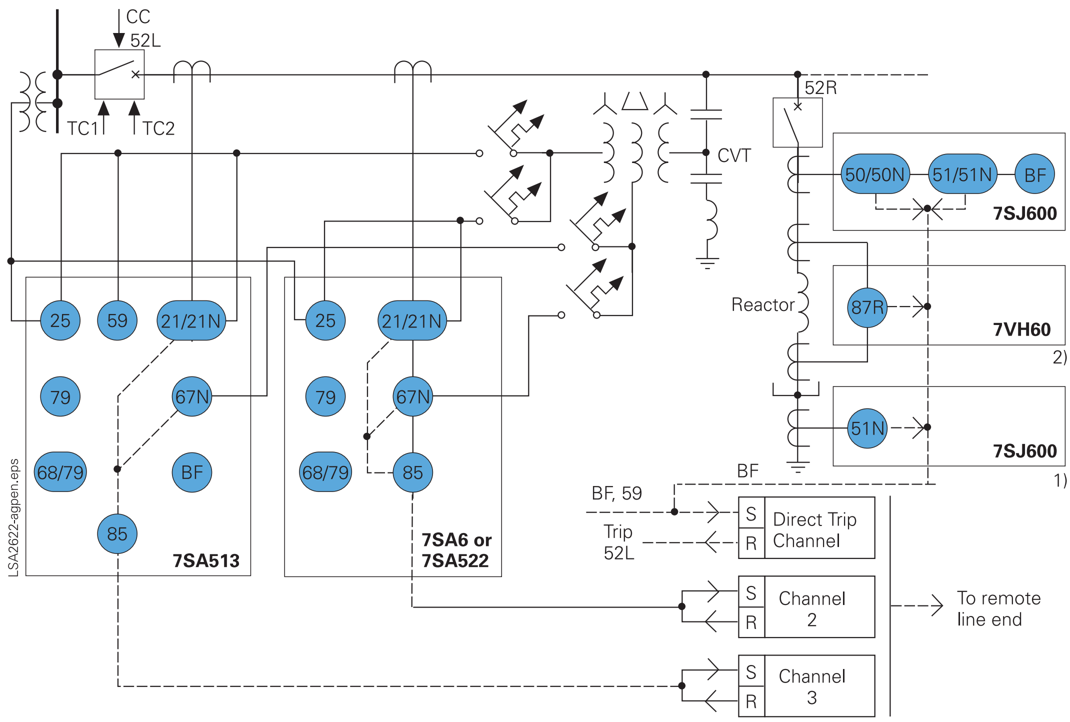


Fig. 2/47

14 Transmission line or cable (with wide-band communication)

General hints:

- Digital PCM-coded communication (with n x 64 kBit/s channels) between line ends is becoming more and more frequently available, either directly by optical or microwave point-to-point links, or via a general purpose digital communication network.

  In both cases, the relay type current differential protection 7SD52/61 can be applied. It provides absolute phase and zone-selectivity by phase-segregated measurement, and is not affected by power swing or parallel line zero-sequence coupling effects. It is furthermore a current-only protection that does not need VT connection. For this reason, the adverse effects of CVT transients are not applicable.

  This makes it in particular suitable for double and multi-circuit lines where complex fault situations can occur.

  The 7SD5/61 can be applied to lines up to about 120 km in direct relay-to-relay connection via dedicated optical fiber cores (see also application **10**), and also to much longer distances up to about 120 km by using separate PCM devices for optical fiber or microwave transmission.

  The 7SD5/61 then uses only a small part (64-512 kBit/s) of the total transmission capacity being in the order of Mbits/s.

- The 7SD52/61 protection relays can be combined with the distance relay 7SA52 or 7SA6 to form a redundant protection system with dissimilar measuring principles complementing each other. This provides the highest degree of availability. Also, separate signal transmission ways should be used for main 1 and main 2 line protection, e.g. optical fiber or microwave, and power-line carrier (PLC).

  The current comparison protection has a typical operating time of 15 ms for faults on 100 % line length including signaling time.

General hints for Fig. 2/49:

- SIPROTEC 7SD5 offers fully redundant differential and distance relays accommodated in one single bay control unit and provides high-speed operation of both relays and excellent fault coverage, even under complicated conditions. Precise distance-to-fault location avoids time consuming line patrolling and reduces the down time of the line to a minimum.

  The high-speed distance relay operates fully independent from the differential relay. Back-up zones provide remote back-up for upstream and downstream lines and other power system components.

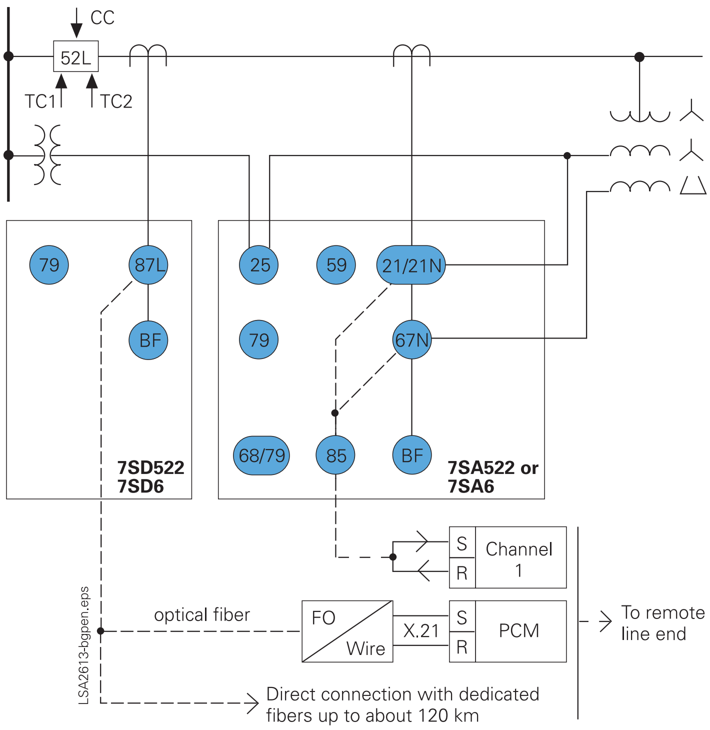


Fig. 2/48

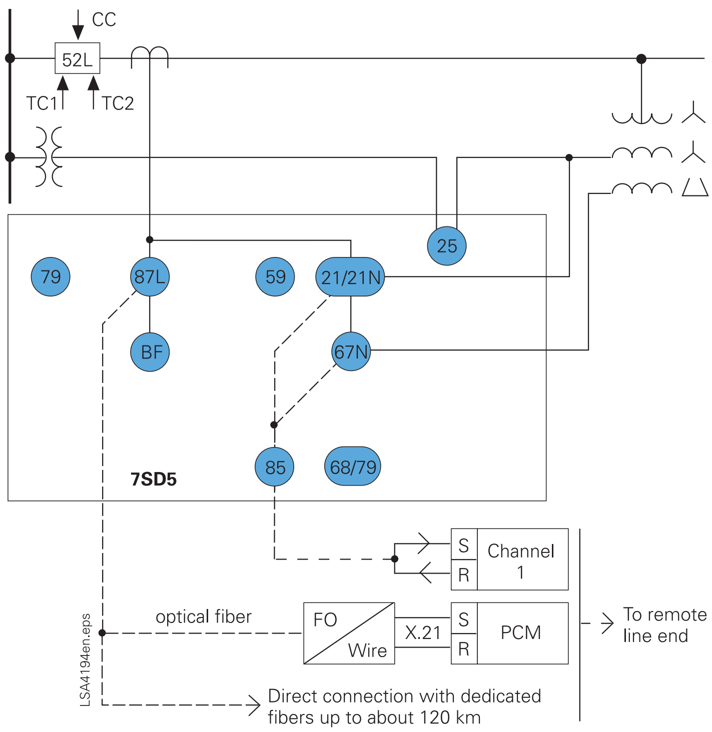


Fig. 2/49

Typical Protection Schemes

15 Transmission line, breaker-and-a-half terminal

Notes for Fig. 2/50 and 2/51:

1) When the line is switched off and the line isolator is open, high through-fault currents in the diameter may cause maloperation of the distance relay due to unequal CT errors (saturation).

Normal practice is therefore to block the distance protection (21/21N) and the directional earth-fault protection (67N) under this condition via an auxiliary contact of the line isolator. Instead, a standby overcurrent function (50/51N, 51/51N) is released to protect the remaining stub between the breakers ("stub" protection).

2) Overvoltage protection only with 7SA6/52.

General hints:

- The protection functions of one diameter of a breaker-and-a-half arrangement are shown.
- The currents of two CTs have each to be summed up to get the relevant line currents as input for main 1 and 2 line protection.

The location of the CTs on both sides of the circuit-breakers is typical for substations with dead-tank circuit-breakers. Live-tank circuit-breakers may have CTs only on one side to reduce cost. A fault between circuit-breakers and CT (end fault) may then still be fed from one side even when the circuit-breaker has opened. Consequently, final fault clearing by cascaded tripping has to be accepted in this case.

The 7VK61 relay provides the necessary end fault protection function and trips the circuit-breakers of the remaining infeeding circuits.

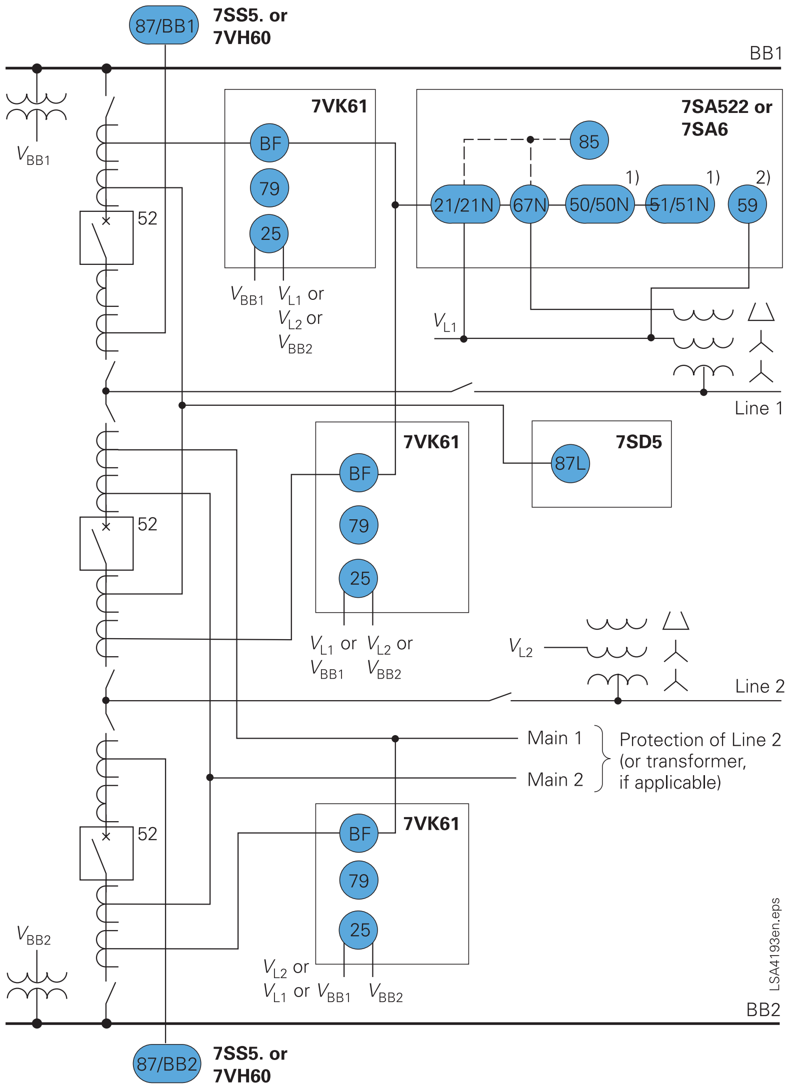


Fig. 2/50

General hints for Fig. 2/50 and 2/51:

- For the selection of the main 1 and main 2 line protection schemes, the comments of application examples **13** and **14** apply.
- Auto-reclosure (79) and synchro-check function (25) are each assigned directly to the circuit-breakers and controlled by main 1 and 2 line protection in parallel. In case of a line fault, both adjacent circuit-breakers have to be tripped by the line protection. The sequence of auto-reclosure of both circuit-breakers or, alternatively, the auto-reclosure of only one circuit-breaker and the manual closure of the other circuit-breaker, may be made selectable by a control switch.
- A coordinated scheme of control circuits is necessary to ensure selective tripping interlocking and reclosing of the two circuit-breakers of one line (or transformer feeder).
- The voltages for synchro-check have to be selected according to the circuit-breaker and disconnector (isolator) position by a voltage replica circuit.

General hints for Fig. 2/51:

- In this optimized application, the 7VK61 is only used for the center breaker. In the line feeders, functions 25, 79 and BF are also performed by transmission line protection 7SA*.

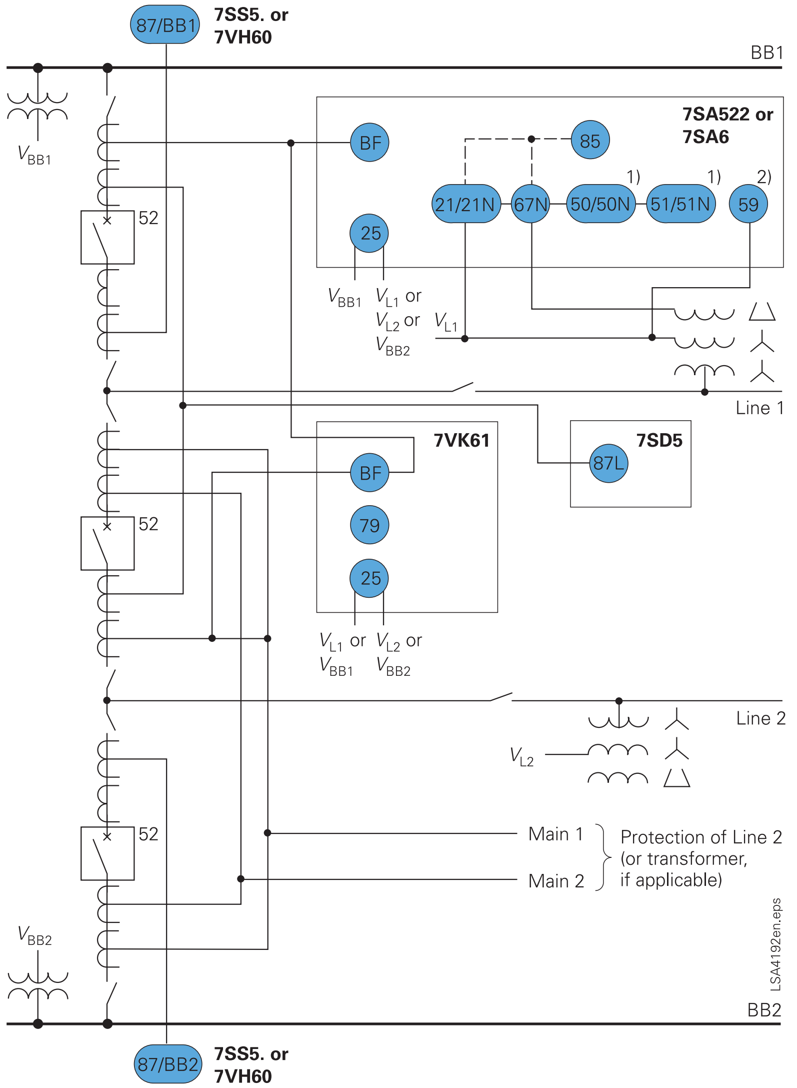


Fig. 2/51

Notes 1) and 2) see page 2/30.

Typical Protection Schemes

Transformers

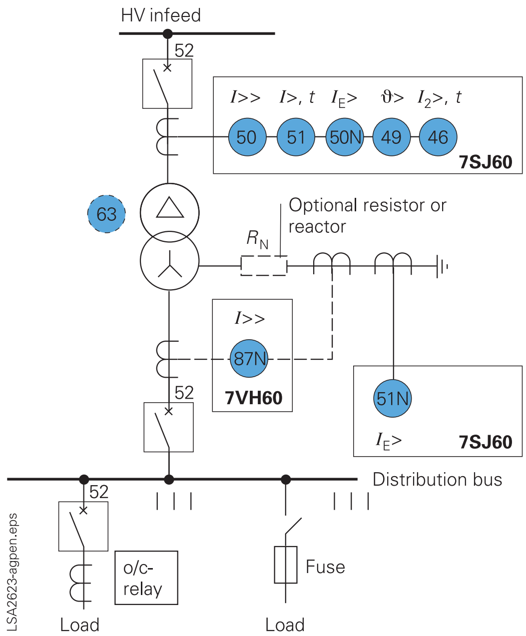


Fig. 2/52

16 Small transformer infeed

General hints:

- Earth faults on the secondary side are detected by current relay 51N which, however, has to be time-graded against downstream feeder protection relays.
  The restricted earth-fault relay 87N can optionally be applied to achieve fast clearance of earth faults in the transformer secondary winding.
  Relay 7VH60 is of the high-impedance type and requires class X CTs with equal transformation ratio.
- Primary circuit-breaker and relay may be replaced by fuses.

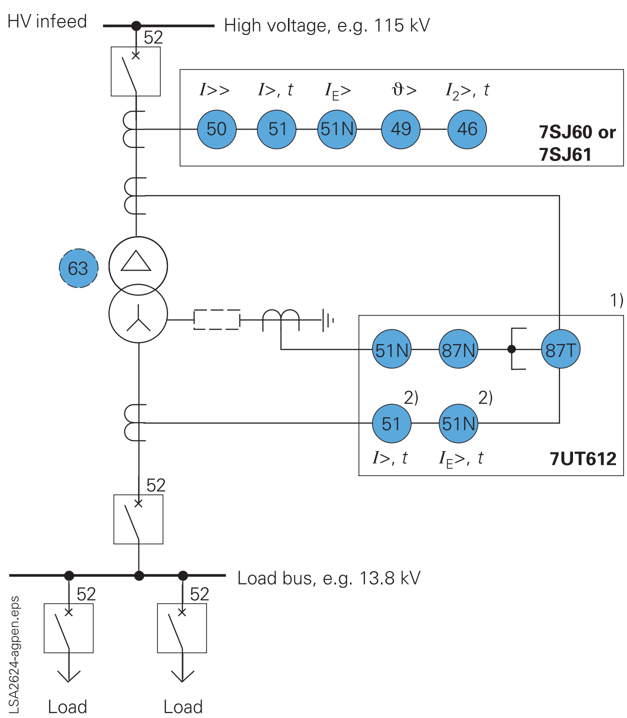


Fig. 2/53

17 Large or important transformer infeed

General hint:

- Relay 7UT612 provides numerical ratio and vector group adaptation. Matching transformers as used with traditional relays are therefore no longer applicable.

Notes:

1) If an independent high-impedance-type earth-fault function is required, the 7VH60 earth-fault relay can be used instead of the 87N inside the 7UT612. However, class X CT cores would additionally be necessary in this case. (See small transformer protection)

2) 51 and 51N may be provided in a separate 7SJ60 if required.

18 Dual infeed with single transformer

General hints:

- Line CTs are to be connected to separate stabilizing inputs of the differential relay 87T in order to assure stability in case of line through-fault currents.
- Relay 7UT613 provides numerical ratio and vector group adaptation. Matching transformers, as used with traditional relays, are therefore no longer applicable.

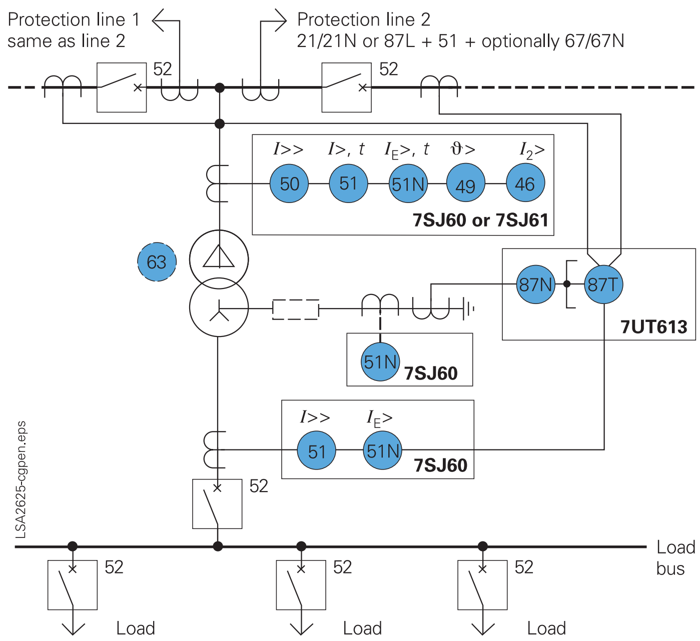


Fig. 2/54

19 Parallel incoming transformer feeders

Note:

1) The directional functions 67 and 67N do not apply for cases where the transformers are equipped with transformer differential relays 87T.

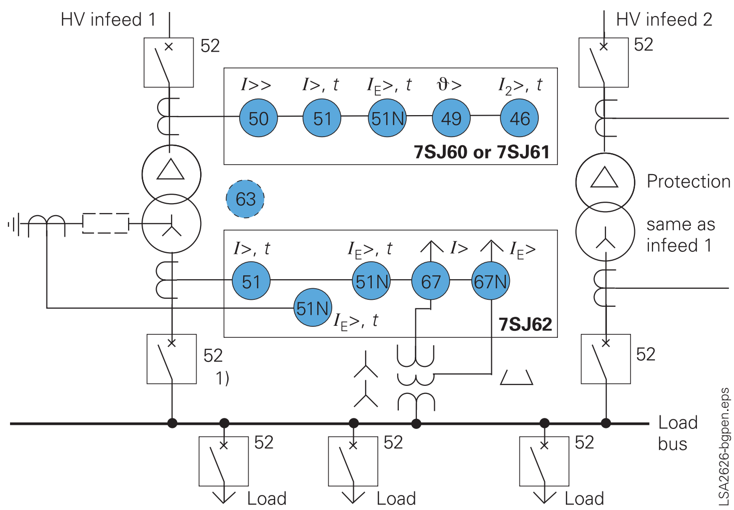


Fig. 2/55

20 Parallel incoming transformer feeders with bus tie

General hints:

- Overcurrent relay 51, 51N each connected as a partial differential scheme. This provides simple and fast busbar protection and saves one time-grading step.

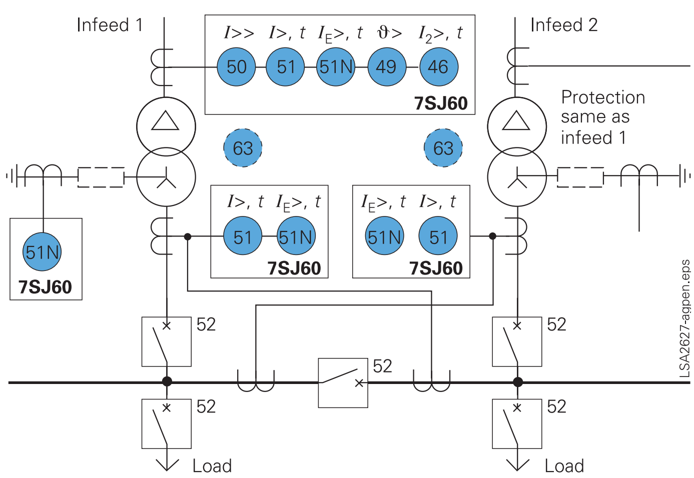


Fig. 2/56

Typical Protection Schemes

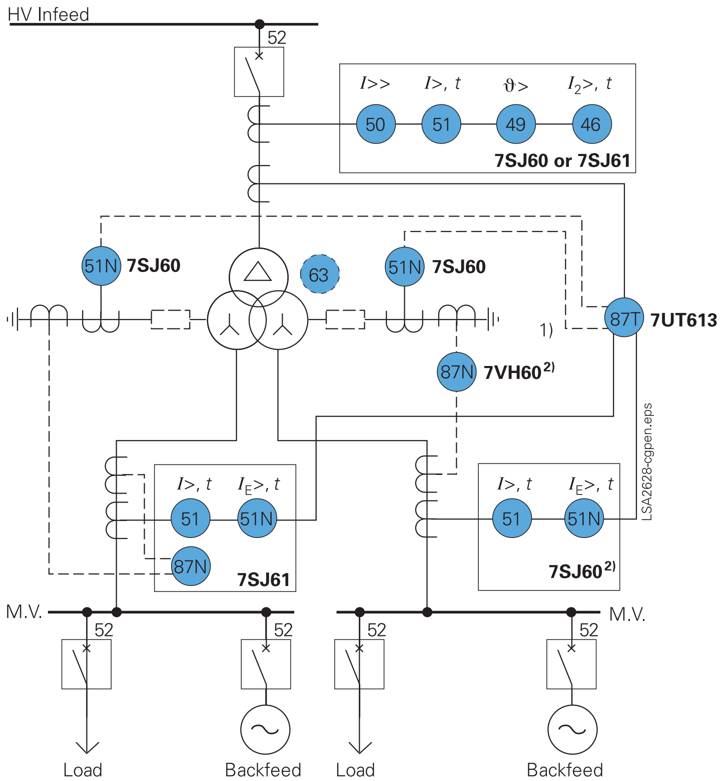


Fig. 2/57

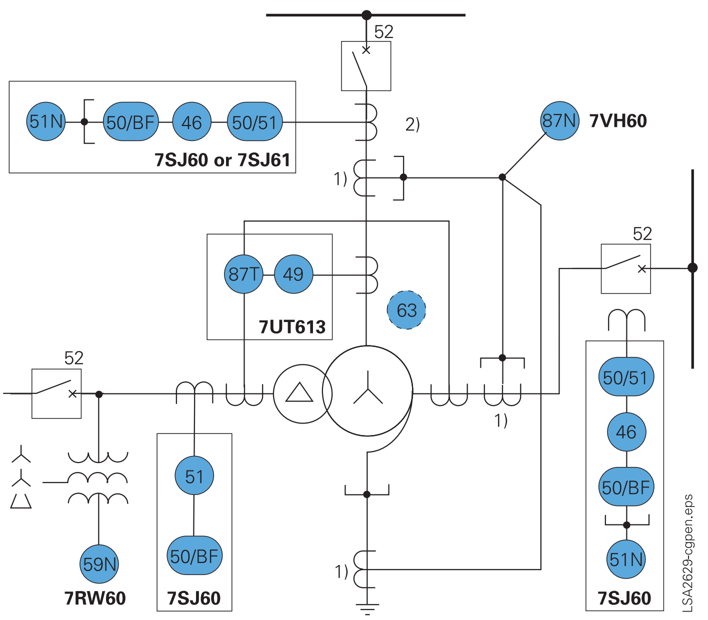


Fig. 2/58

21 Three-winding transformer

Notes:

1) The zero-sequence current must be blocked before entering the differential relay with a delta winding in the CT connection on the transformer sides with earthed starpoint. This is to avoid false operation during external earth faults (numerical relays provide this function by calculation). About 30 % sensitivity, however, is then lost in case of internal faults. Optionally, the zero-sequence current can be regained by introducing the winding neutral current in the differential relay (87T). Relay type 7UT613 provides two current inputs for this purpose. By using this feature, the earth-fault sensitivity can be upgraded again to its original value.

   Restricted earth-fault protection (87T) is optional. It provides backup protection for earth faults and increased earth-fault sensitivity (about 10 % I_N, compared to about 20 to 30 % I_N of the transformer differential relay). Separate class X CT-cores with equal transmission ratio are additionally required for this protection.

2) High impedance and O/C in one 7SJ61.

General hint:

- In this example, the transformer feeds two different distribution networks with cogeneration. Restraining differential relay inputs are therefore provided at each transformer side.
  If both distribution networks only consume load and no through-feed is possible from one MV network to the other, parallel connection of the CTs of the two MV transformer windings is admissible allowing the use of a two-winding differential relay (7UT612).

22 Autotransformer

Notes:

1) 87N high-impedance protection requires special class X current transformer cores with equal transformation ratio.

2) The 7SJ60 relay can alternatively be connected in series with the 7UT613 relay to save this CT core.

General hint:

- Two different protection schemes are provided: 87T is chosen as low-impedance three-winding version (7UT613). 87N is a single-phase high-impedance relay (7VH60) connected as restricted earth-fault protection. (In this example, it is assumed that the phase ends of the transformer winding are not accessible on the neutral side, i.e. there exists a CT only in the neutral earthing connection.)

23 Large autotransformer bank

General hints:

- The transformer bank is connected in a 1½ circuit-breaker arrangement.
  Duplicated differential protection is proposed:
  Main 1: Low-impedance differential protection 87TL (7UT613) connected to the transformer bushing CTs.
  Main 2: High-impedance differential overall protection 87TL (7VH60). Separate class X cores and equal CT ratios are required for this type of protection.
- Backup protection is provided by distance protection relay (7SA52 and 7SA6), each "looking" with an instantaneous first zone about 80 % into the transformer and with a time-delayed zone beyond the transformer
- The tertiary winding is assumed to feed a small station supply network with isolated neutral.

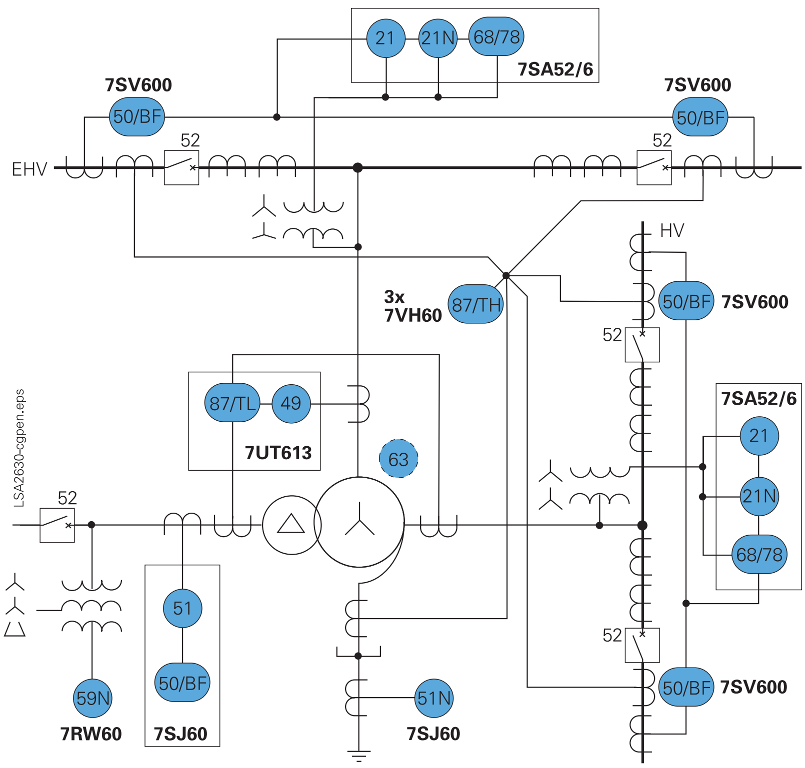


Fig. 2/59

Motors [1)]

24 Small and medium-sized motors < about 1 MW

a) With effective or low-resistance earthed infeed ($I_E \geq I_{N\ Motor}$)

General hint:

- Applicable to low-voltage motors and high-voltage motors with low-resistance earthed infeed ($I_E \geq I_{N\ Motor}$)

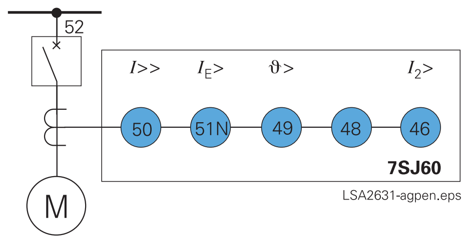


Fig. 2/60

b) With high-resistance earthed infeed ($I_E \leq I_{N\ Motor}$)

Notes:

1) Core-balance CT.
2) Sensitive directional earth-fault protection 67N only applicable with infeed from isolated or Peterson-coil-earthed network (For dimensioning of the sensitive directional earth-fault protection, see also application circuit No. ***30***)
3) The 7SJ602 relay can be applied for isolated and compensated networks.

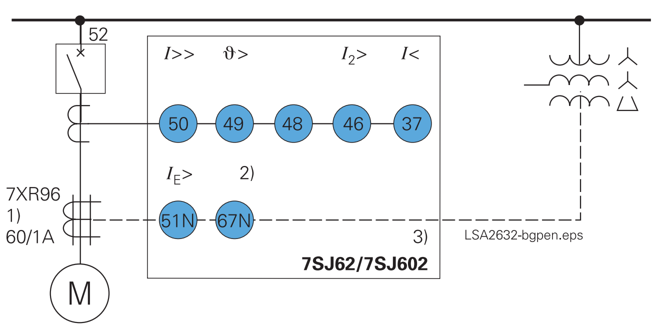


Fig. 2/61

1) For further applications of motor protection see part 12 of this catalog.

Typical Protection Schemes

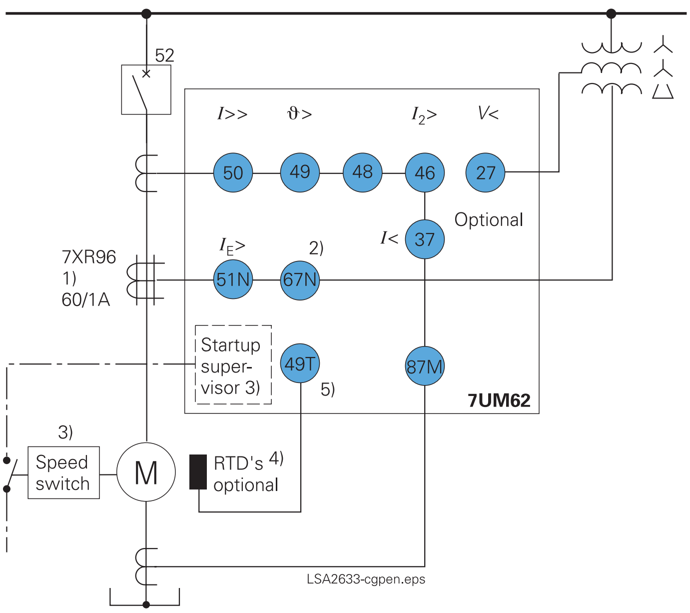


Fig. 2/62

25 Large HV motors > about 1 MW

Notes:

1) Core-balance CT.

2) Sensitive directional earth-fault protection 67N only applicable with infeed from isolated or Peterson-coil-earthed network

3) This function is only needed for motors where the startup time is longer than the safe stall time t_E. According to IEC 60079-7, the t_E-time is the time needed to heat up AC windings, when carrying the starting current I_A, from the temperature reached in rated service and at maximum ambient temperature to the limiting temperature. A separate speed switch is used to supervise actual starting of the motor. The motor circuit-breaker is tripped if the motor does not reach speed in the preset time. The speed switch is part of the motor supply itself.

4) Pt100, Ni100, Ni120

5) 49T only available with external temperature monitoring device (7XV5662)

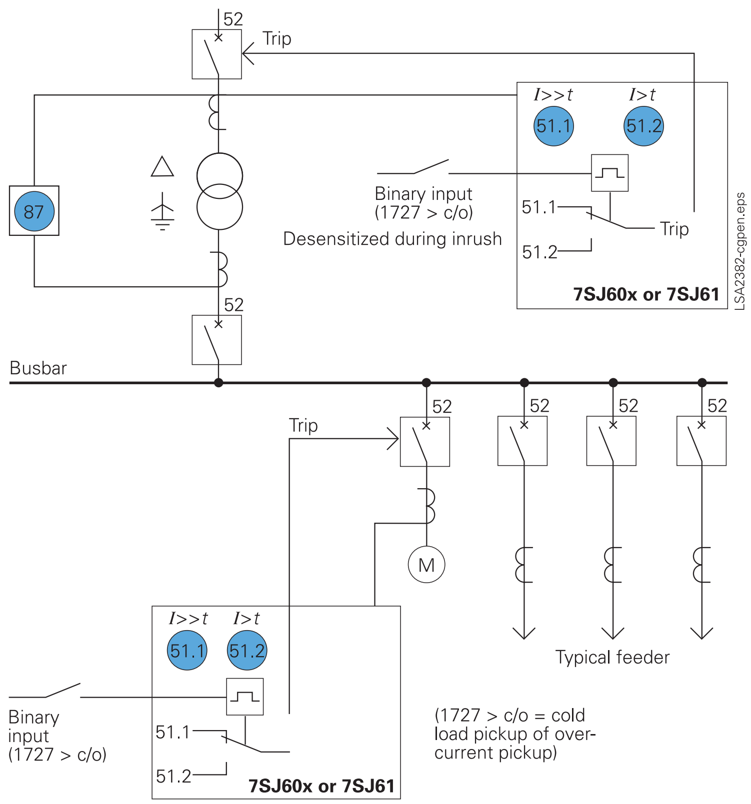


Fig. 2/63

26 Cold load pickup

By means of a binary input which can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable amount of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady state conditions.

Generators

27 Generators < 500 kW

(Fig. 2/64 and 2/65)

Note:

1) If a core-balance CT is provided for sensitive earth-fault protection, relay 7SJ602 with separate earth-current input can be used.

28 Generators, typically 1–3 MW

(Fig. 2/66)

Note:

1) Two VTs in V connection are also sufficient.

29 Generators > 1–3 MW

(Fig. 2/67)

Notes:

1) Functions 81 and 59 are only required where prime mover can assume excess speed and the voltage regulator may permit rise of output voltage above upper limit.

2) Differential relaying options:
– Low-impedance differential protection 87.
– Restricted earth-fault protection with low ohmic resistance-earthed neutral (see Fig. 2/65).

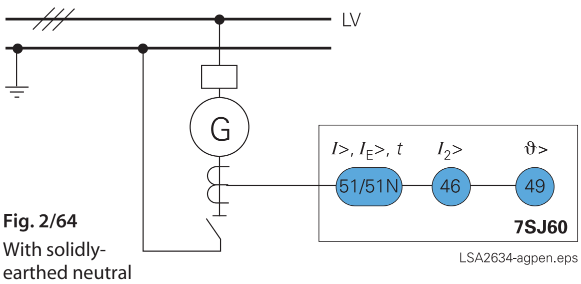


Fig. 2/64
With solidly-earthed neutral

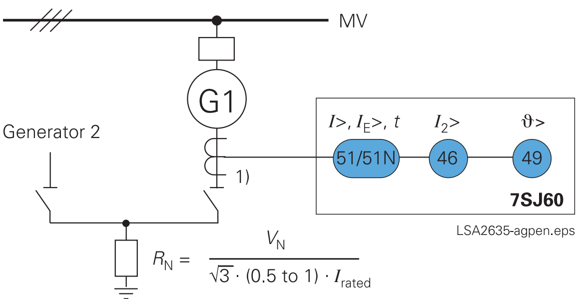


Fig. 2/65
With resistance-earthed neutral

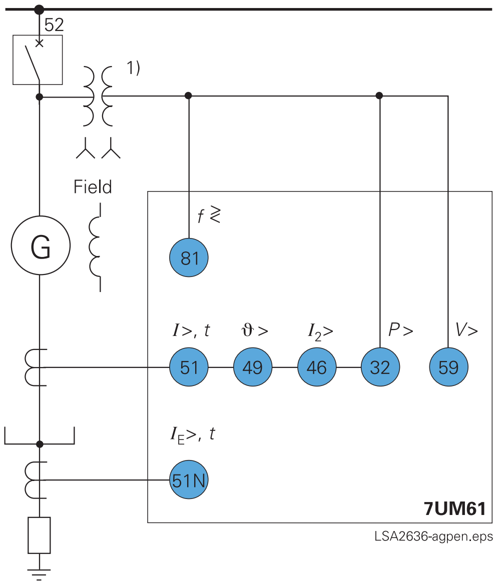


Fig. 2/66

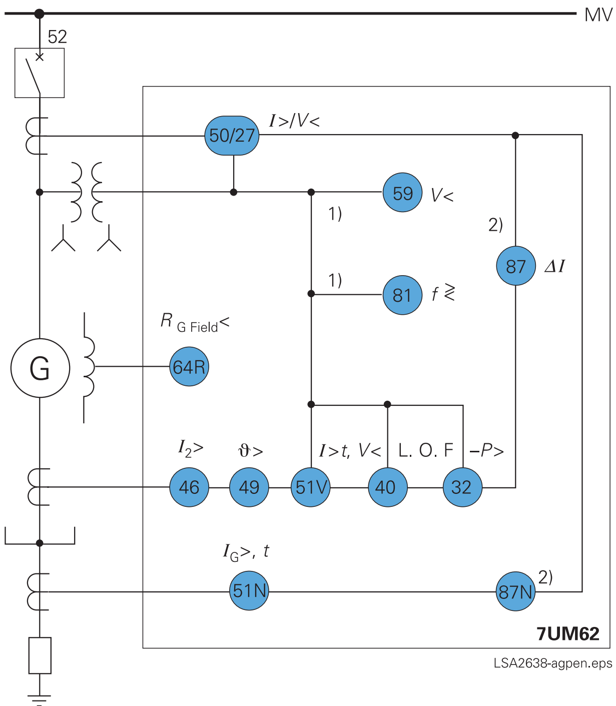


Fig. 2/67

Typical Protection Schemes

29 Generators > 5–10 MW feeding into a network with isolated neutral

(Fig. 2/68)

Relay earth-current input connected to:	Minimum relay setting:	Comments:
Core-balance CT 60/1 A: 1 single CT 2 parallel CTs 3 parallel Cts 4 parallel CTs	 2 mA 5 mA 8 mA 12 mA	
Three-phase CTs in residual (Holmgreen) connection	1 A CT: 50 mA 5 A CT: 200 mA	In general not suitable for sensitive earth-fault protection
Three-phase CTs in residual (Holmgreen) connection with special factory calibration to minimum residual false currents (≤ 2 mA)	2 - 3 ‰ of secondary rated CT current $I_{n\ SEC}$ 10 - 15 mA with 5 A CTs	1 A CTs are not recommended in this case

General hints:

- The setting range of the directional earth-fault protection 67N in the 7UM6 relay is 2–1000 mA. Depending on the current transformer accuracy a certain minimum setting is required to avoid false operation on load or transient currents.
- In practice, efforts are generally made to protect about 90 % of the machine winding, measured from the machine terminals. The full earth current for a terminal fault must then be ten times the setting value which corresponds to the fault current of a fault at 10 % distance from the machine neutral.

For the most sensitive setting of 2 mA, we therefore need 20 mA secondary earth current, corresponding to (60/1) x 20 mA = 1.2 A primary

If sufficient capacitive earth current is not available, an earthing transformer with resistive zero-sequence load can be installed as earth-current source at the station busbar.
The smallest standard earthing transformer TGAG 3541 has a 20 s short time rating of S_G = 27 kVA

In a 5 kV network, it would deliver:

$$I_{G\,20\,s} = \frac{\sqrt{3}\cdot S_G}{V_N} = \frac{\sqrt{3}\cdot 27{,}000\,\text{VA}}{5000\ \text{V}} = 9.4\ \text{A}$$

corresponding to a relay input current of 9.4 A x 1/60 A = 156 mA. This would provide a 90 % protection range with a setting of about 15 mA, allowing the use of 4 parallel connected core-balance CTs. The resistance at the 500 V open-delta winding of the earthing transformer would then have to be designed for

$R_B = V^2_{SEC} / S_G$ = 500 V² / 27,000 VA = 9.26 Ω (27 kW, 20 s).

For a 5 MVA machine and 600/5 A CTs with special calibration for minimum residual false current, we would get a secondary current of $I_{G\ SEC}$ = 9.4 A/ (600/5) = 78 mA.

With a relay setting of 12 mA, the protection range would in this case be $100\left(1-\frac{12}{78}\right) = 85\ \%$.

Notes:
See following page

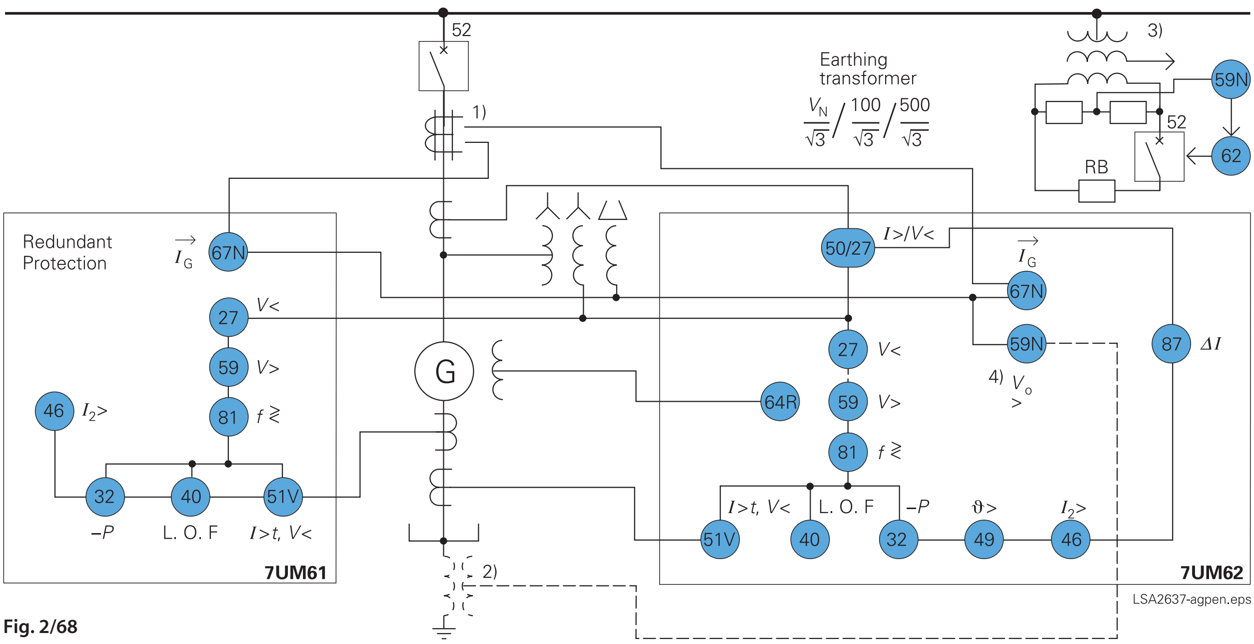


Fig. 2/68

Notes (Fig. 2/68):

1) The standard core-balance CT 7XR96 has a transformation ratio of 60/1 A.

2) Instead of an open-delta winding at the terminal VT, a single-phase VT at the machine neutral could be used as zero-sequence polarizing voltage.

3) The earthing transformer is designed for a short-time rating of 20 seconds. To prevent overloading, the load resistor is automatically switched off by a time-delayed zero-sequence voltage relay (59N + 62) and a contactor (52).

4) During the startup time of the generator with open circuit-breaker the earthing source is not available. To ensure earth-fault protection during this time interval, an auxiliary contact of the circuit-breaker can be used to change over the directional earth-fault relay function (67N) to a zero-sequence voltage detection function via binary input.

31 Generators > 50 - 100 MW in generator transformer unit connection

(Fig. 2/69)

Notes:

1) 100 % stator earth-fault protection based on 20 Hz voltage injection

2) Sensitive rotor earth-fault protection based on 1–3 Hz voltage injection

3) Non-electrical signals can be incoupled in the protection via binary inputs (BI)

4) Only used functions shown, further integrated functions available in each relay type (see Product Selection, pages 1/2 – 1/5).

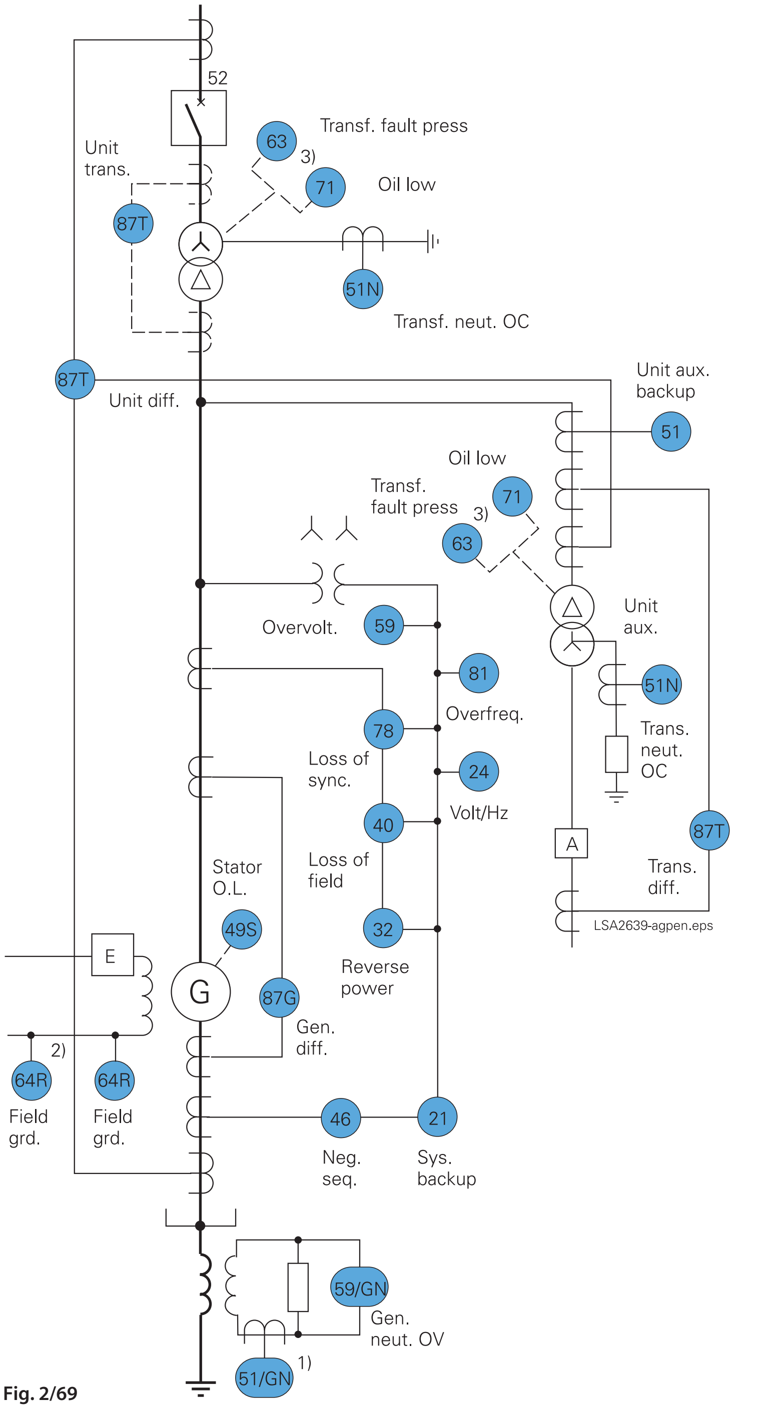


Fig. 2/69

Relay type	Functions 4)	Number of relay required
7UM62	21 24 32 40 46 49 51GN 1) 59GN 59 64R 64R 2) 78 81 87G via BI: 71 63	2
7UM61	51 51N optionally 24 59 81 via BI: 71 63	1
7UT612	87T 51N	1 optionally 2
7UT613	87T	1

LSA2640-bgpen.eps

Typical Protection Schemes

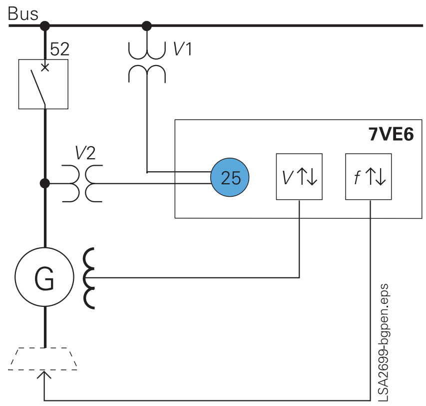


Fig. 2/70

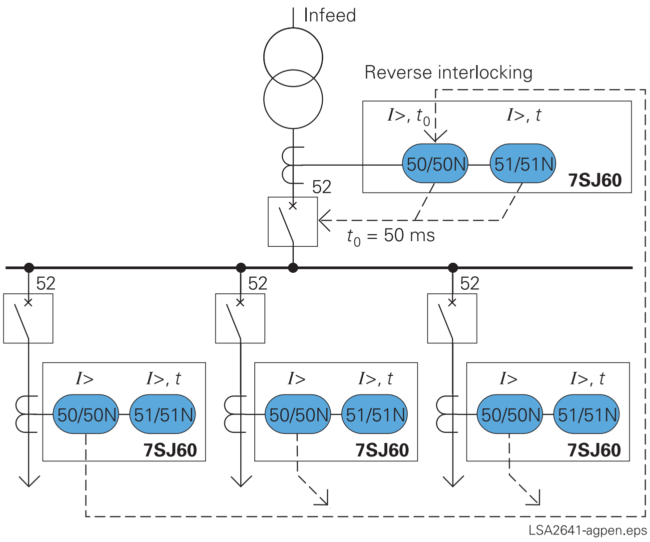


Fig. 2/71

32 Synchronization of a generator

Fig. 2/70 shows a typical connection for synchronizing a generator. Paralleling device 7VE6 acquires the line and generator voltage, and calculates the differential voltage, frequency and phase angle. If these values are within a permitted range, an CLOSE command is output after a specified circuit-breaker make time. If these variables are out of range, the paralleling device automatically sends a command to the voltage and speed controller. For example, if the frequency is outside the range, an actuation command is sent to the speed controller. If the voltage is outside the range, the voltage controller is activated.

Busbars

33 Busbar protection by o/c relays with reverse interlocking

General hint:

- Applicable to distribution busbars without substantial (< 0.25 x I_N) backfeed from the outgoing feeders.

34 High-impedance busbar protection

General hints:

- Normally used with single busbar and 1½ breaker schemes.
- Requires separate class X current transformer cores. All CTs must have the same transformation ratio.

Note:

1) A varistor is normally applied across the relay input terminals to limit the voltage to a value safely below the insulation voltage of the secondary circuits (see page 2/51).

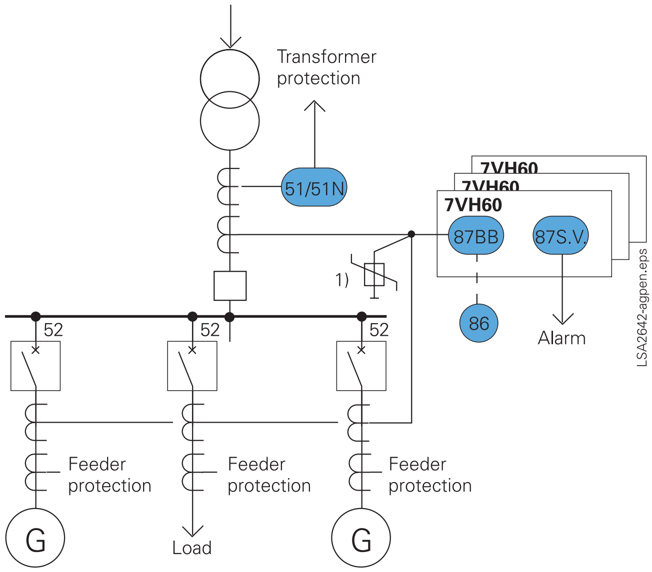


Fig. 2/72

35 Low-impedance busbar protection 7SS60

General hints:

- Normally used with single busbar, 1½ breaker and double busbar schemes.
- Different CT transformation ratios can be adapted by matching transformers.
- Unlimited number of feeders.
- Feeder protection can be connected to the same CT core.

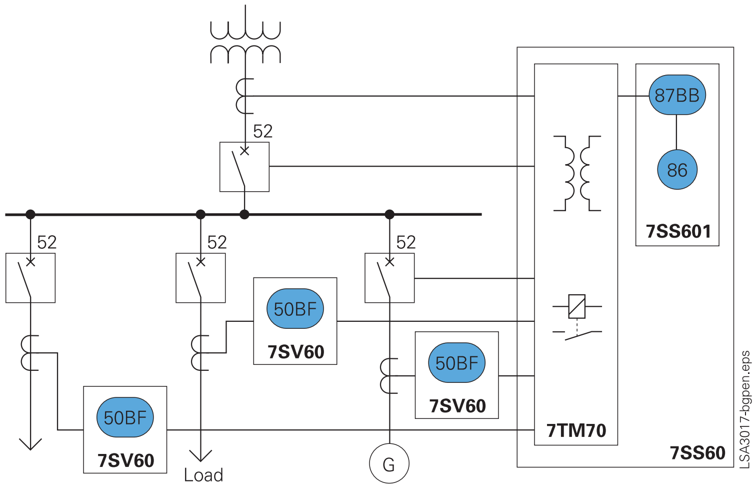


Fig. 2/73

36 Low-impedance busbar protection 7SS52

General hints:

- Preferably used for multiple busbar schemes where an isolator replica is necessary.
- The numerical busbar protection 7SS5 provides additional breaker failure protection.
- CT transformation ratios can be different, e.g. 600/1 A in the feeders and 2000/1 A at the bus tie.
- The protection system and the isolator replica are continuously self-monitored by the 7SS52.
- Feeder protection can be connected to the same CT core.

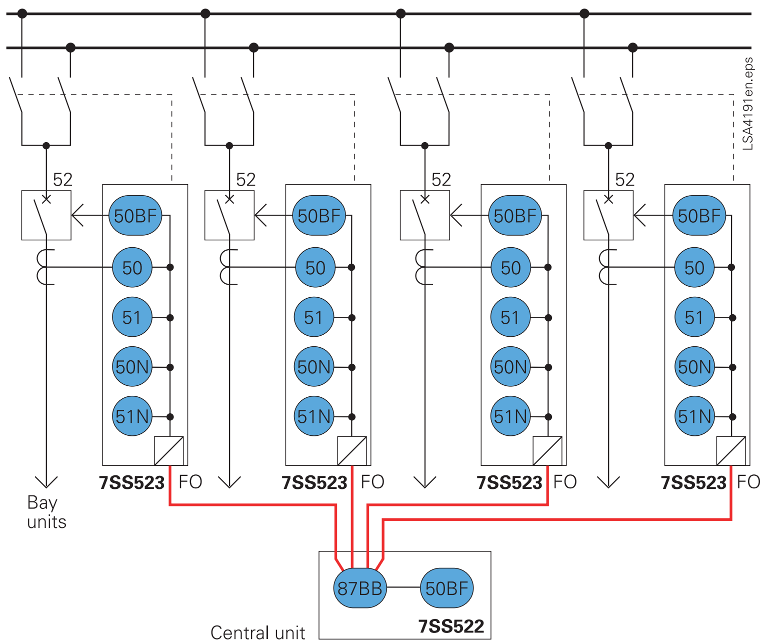


Fig. 2/74

Typical Protection Schemes

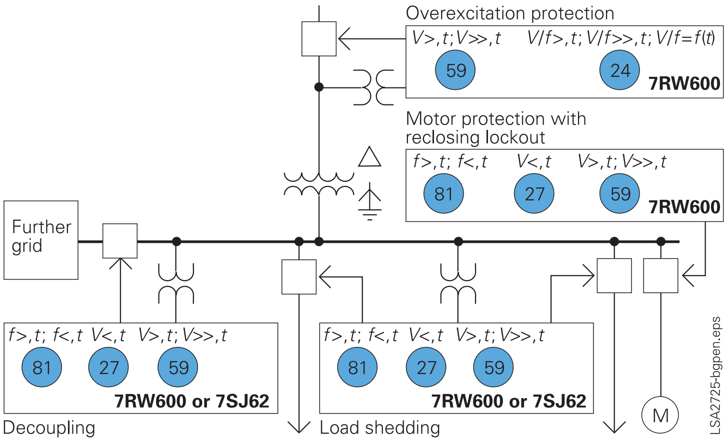


Fig. 2/75

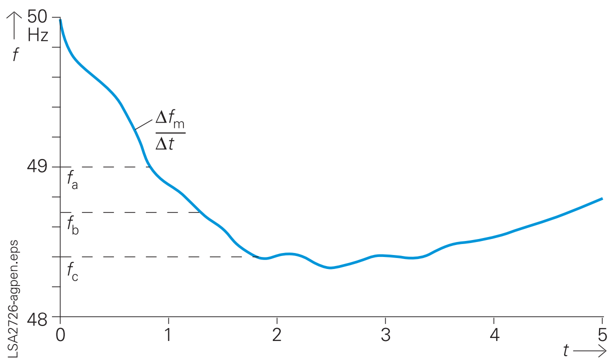


Fig. 2/76

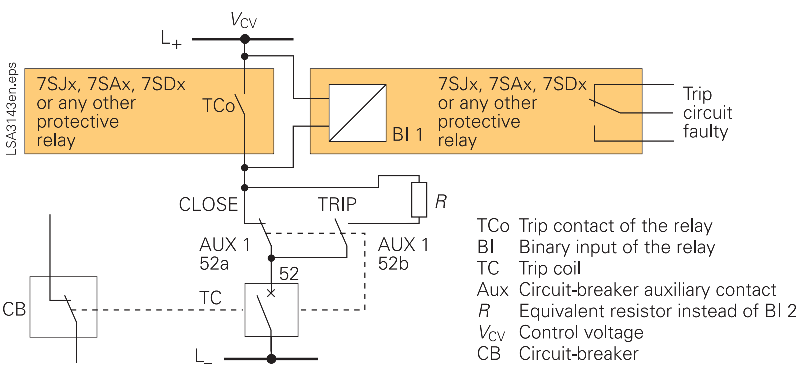


Fig. 2/77

Networks

37 Load shedding
(Fig. 2/75)

In unstable networks (e.g. solitary networks, emergency power supply in hospitals), it may be necessary to isolate selected loads from the network to prevent overload of the overall network. The overcurrent-time protection functions are effective only in the case of a short-circuit. Overloading of the generator can be measured as a frequency or voltage drop.
(Protection functions 27 and 81 available in 7RW600 and 7SJ6..)

38 Load shedding with rate-of-frequency-change protection
(Fig. 2/76)

The rate-of-frequency-change protection calculates, from the measured frequency, the gradient or frequency change d*f*/d*t*. It is thus possible to detect and record any major active power loss in the power system, to disconnect certain consumers accordingly, and to restore the system to stability. Unlike frequency protection, rate-of-frequency-change protection already reacts before the frequency threshold is undershot. To ensure effective protection settings, it is recommended to consider requirements throughout the power system as a whole. The rate-of-frequency-change protection function can also be used for the purposes of system decoupling.

Rate-of-frequency-change protection can also be enabled by an underfrequency state.

39 Trip circuit supervision (ANSI 74TC)
(Fig. 2/77)

One or two binary inputs can be used for the trip circuit supervision.

40 Disconnecting facility with flexible protection function

(Fig. 2/78)

General hint:
The SIPROTEC protection relay 7SJ64 disconnects the switchgear from the utility power system if the generator feeds energy back into the power system (protection function P reverse>). This functionality is achieved by using flexible protection. Disconnection also takes place in the event of frequency or voltage fluctuations in the utility power system (protection functions *f*<, *f*>, *V*<, *V*>, I_{dir}>, I_{Edir}>/ 81, 27, 59, 67, 67N).

For more details on "flexible protection", please refer to page 5/163.

Notes:

1) The transformer is protected by differential protection and inverse or definite-time overcurrent-time protection functions for the phase currents. In the event of a fault, the circuit-breaker CB1 on the utility side is tripped by a remote link. Circuit-breaker CB2 is tripped additionally.

2) Overcurrent-time protection functions protect feeders 1 and 2 against short-circuits and overload caused by the connected loads. Both the phase currents and the zero currents of the feeders can be protected by inverse and definite-time overcurrent-time stages. The circuit-breakers CB4 and CB5 are tripped in the event of a fault.

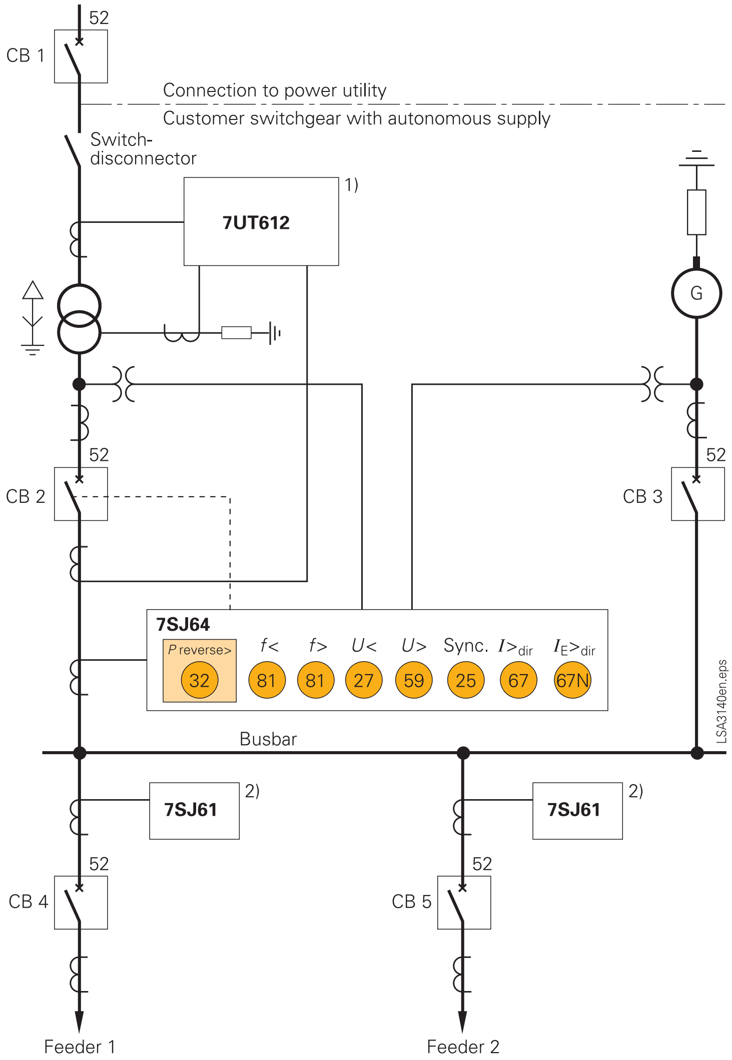
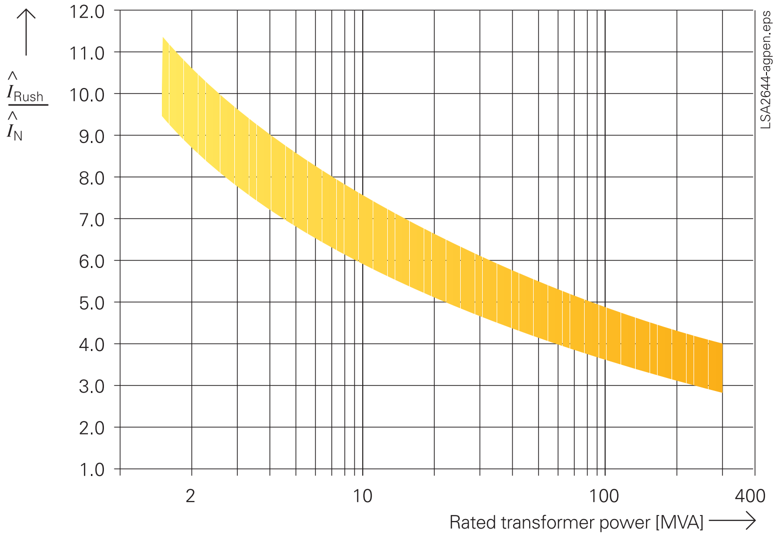


Fig. 2/78 Example of a switchgear with autonomous generator supply

2

Protection Coordination

Peak value of inrush current



Time constant of inrush current

Nominal power (MVA)	0.5 … 1.0	1.0 … 10	> 10
Time constant (s)	0.16 … 0.2	0.2 … 1.2	1.2 … 720

Fig. 2/79

Typical applications and functions

Relay operating characteristics and their setting must be carefully coordinated in order to achieve selectivity. The aim is basically to switch off only the faulted component and to leave the rest of the power system in service in order to minimize supply interruptions and to assure stability.

Sensitivity

Protection should be as sensitive as possible to detect faults at the lowest possible current level. At the same time, however, it should remain stable under all permissible load, overload and through-fault conditions. For further information see: http://www.siemens.com/systemplanning. The Siemens engineering programs SINCAL and SIGRADE are especially designed for selective protection grading of protection relay systems. They provide short-circuit calculations, international standard characteristics of relays, fuses and circuit-breakers for easy protection grading with respect to motor starting, inrush phenomena and equipment damage curves.

Phase-fault o/c relays

The pickup values of phase o/c relays are normally set 30 % above the maximum load current, provided that sufficient short-circuit current is available. This practice is recommended in particular for mechanical relays with reset ratios of 0.8 to 0.85. Numerical relays have high reset ratios near 0.95 and allow therefore about 10 % lower setting. Feeders with high transformer and/or motor load require special consideration.

Transformer feeders

The energizing of transformers causes inrush currents that may last for seconds, depending on their size (Fig. 2/79).
Selection of the pickup current and assigned time delay have to be coordinated so that the inrush current decreases below the relay o/c reset value before the set operating time has elapsed.
The inrush current typically contains only about 50 % fundamental frequency component. Numerical relays that filter out harmonics and the DC component of the inrush current can therefore be set more sensitive. The inrush current peak values of Fig. 2/79 will be reduced more than to one half in this case.
Some digital relay types have an inrush detection function which may block the trip of the overcurrent protection resulting from inrush currents.

Earth-fault protection relays

Earth-current relays enable a much more sensitive setting, as load currents do not have to be considered (except 4-wire circuits with single-phase load). In solidly and low-resistance earthed systems a setting of 10 to 20 % rated load current can generally be applied. High-resistance earthing requires much more sensitive setting in the order of some amperes primary. The earth-fault current of motors and generators, for example, should be limited to values below 10 A in order to avoid iron burning.
Residual-current relays in the star point connection of CTs can in this case not be used, in particular with rated CT primary currents higher than 200 A. The pickup value of the zero-sequence relay would in this case be in the order of the error currents of the CTs.
A special core-balance CT is therefore used in this case as earth-current sensor. The core-balance CT 7XR96 is designed for a ratio of 60/1 A. The detection of 6 A primary would then require a relay pickup setting of 0.1 A secondary. An even more sensitive setting is applied in isolated or Peterson-coil-earthed networks where very low earth currents occur with single-phase-to-earth faults. Settings of 20 mA and less may then be required depending on the minimum earth-fault current. Sensitive directional earth-fault relays (integrated in the relays 7SJ62, 63, 64, 7SA6) allow settings as low as 5 mA.

Motor feeders

The energization of motors causes a starting current of initially 5 to 6 times the rated current (locked rotor current).

A typical time-current curve for an induction motor is shown in Fig. 2/80.

In the first 100 ms, a fast decaying asymmetrical inrush current appears additionally. With conventional relays it was common practice to set the instantaneous overcurrent stage of the short-circuit protection 20 to 30 % above the locked-rotor current with a short time delay of 50 to 100 ms to override the asymmetrical inrush period.

Numerical relays are able to filter out the asymmetrical current component very rapidly so that the setting of an additional time delay is no longer applicable.

The overload protection characteristic should follow the thermal motor characteristic as closely as possible. The adaptation is made by setting the pickup value and the thermal time constant, using the data supplied by the motor manufacturer. Further, the locked-rotor protection timer has to be set according to the characteristic motor value.

Time grading of o/c relays (51)

The selectivity of overcurrent protection is based on time grading of the relay operating characteristics. The relay closer to the infeed (upstream relay) is time-delayed against the relay further away from the infeed (downstream relay). The calculation of necessary grading times is shown in Fig. 2/82 by an example for definite-time overcurrent relays.

The overshoot times take into account the fact that the measuring relay continues to operate due to its inertia, even when the fault current is interrupted. This may be high for mechanical relays (about 0.1 s) and negligible for numerical relays (20 ms).

Inverse-time relays (51)

For the time grading of inverse-time relays, in principle the same rules apply as for the definite-time relays. The time grading is first calculated for the maximum fault level and then checked for lower current levels (Fig. 2/81).

If the same characteristic is used for all relays, or when the upstream relay has a steeper characteristic (e.g. very much over normal inverse), then selectivity is automatically fulfilled at lower currents.

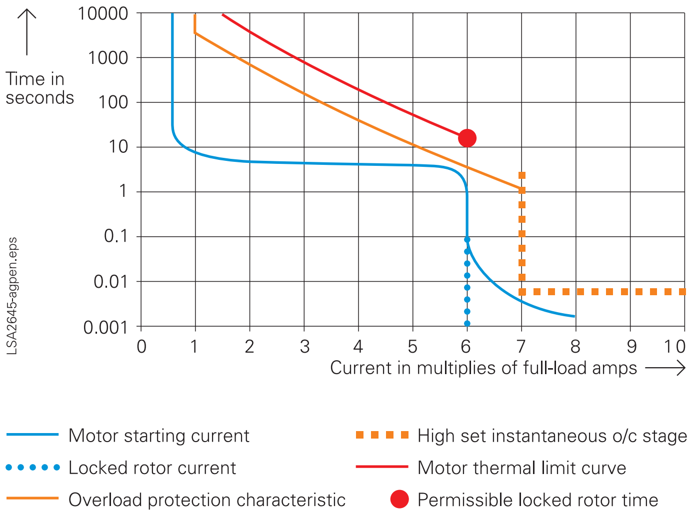


Fig. 2/80
Typical motor current-time characteristics

Differential relay (87)

Transformer differential relays are normally set to pickup values between 20 and 30 % of the rated current. The higher value has to be chosen when the transformer is fitted with a tap changer.

Restricted earth-fault relays and high-resistance motor / generator differential relays are, as a rule, set to about 10 % of the rated current.

Instantaneous overcurrent protection (50)

This is typically applied on the final supply load or on any protection relay with sufficient circuit impedance between itself and the next downstream protection relay. The setting at transformers, for example, must be chosen about 20 to 30 % higher than the maximum through-fault current. The relay must remain stable during energization of the transformer.

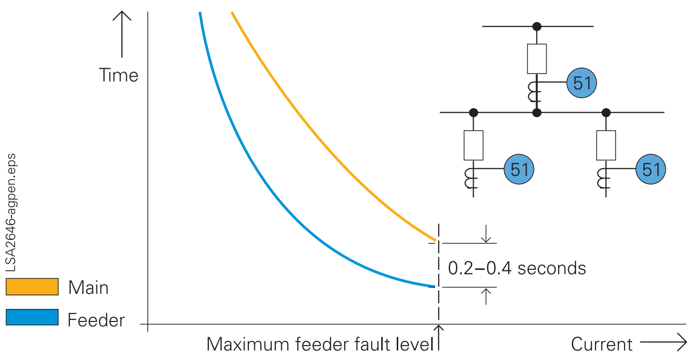
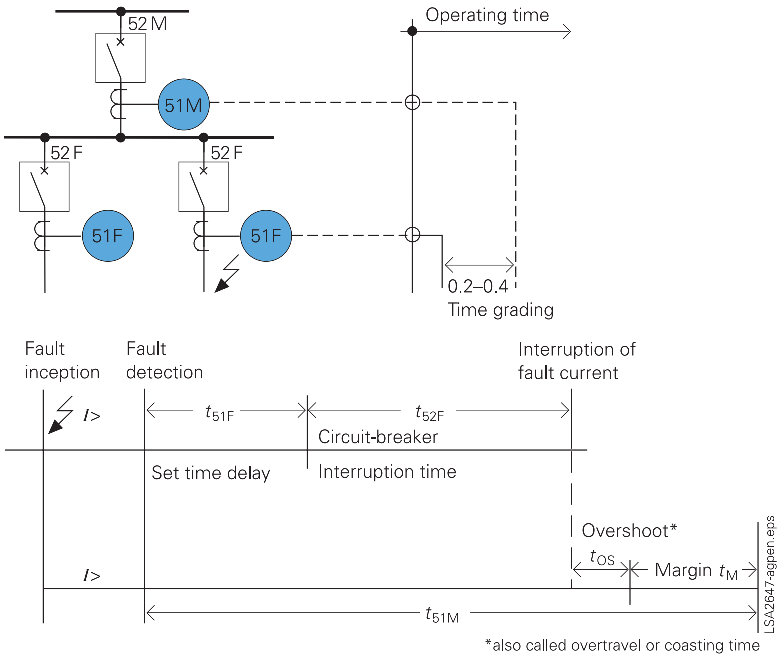


Fig. 2/81
Coordination of inverse-time relays

Protection Coordination

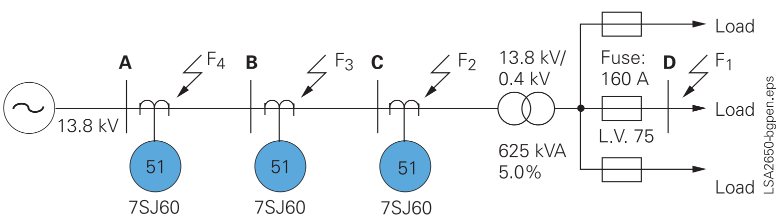


Time grading

$t_{rs} = t_{51M} - t_{51F} = t_{52F} + t_{OS} + t_M$

Example 1	t_{TG} = 0.10 s + 0.15 s + 0.15 s = 0.40 s
Oil circuit-breaker	t_{52F} = 0.10 s
Mechanical relays	t_{OS} = 0.15 s
Safety margin for measuring errors etc.:	t_M = 0.15 s
Example 2	t_{TG} = 0.08 + 0.02 + 0.10 = 0.20 s
Vacuum circuit-breaker	t_{52F} = 0.08 s
Numerical relays	t_{OS} = 0.02 s
Safety margin	t_M = 0.10 s

Fig. 2/82
Time grading of overcurrent-time relays



Station	Max. Load A	$I_{SCC.}$ max:*	CT ratio	I_p/I_N**	I_{prim}*** A	$I/I_p = \frac{I_{SCC.}\max}{I_{prim}}$
A	300	4500	400/5	1.0	400	11.25
B	170	2690	200/5	1.1	220	12.23
C	50	1395	100/5	0.7	70	19.93
D	–	523	–	–	–	–

Fig. 2/83 Time grading of inverse-time relays for a radial feeder

Calculation example

The feeder configuration of Fig. 2/83 and the associated load and short-circuit currents are given. Numerical o/c relays 7SJ60 with normal inverse-time characteristic are applied.

The relay operating times, depending on current, can be derived from the diagram or calculated with the formula given in Fig. 2/84.

The I_p/I_N settings shown in Fig. 2/83 have been chosen to get pickup values safely above maximum load current.

This current setting shall be lowest for the relay farthest downstream. The relay further upstream shall each have equal or higher current setting.

The time multiplier settings can now be calculated as follows:

Station C:

- For coordination with the fuses, we consider the fault in location F_1.
  The short-circuit current $I_{scc.}$ max. related to 13.8 kV is 523 A.
  This results in 7.47 for I/I_p at the o/c relay in location C.
- With this value and $T_p = 0.05$ we derive from Fig. 2/84 an operating time of $t_A = 0.17$ s.

This setting was selected for the o/c relay to get a safe grading time over the fuse on the transformer low-voltage side.
The setting values for the relay at station C are therefore:

- Pickup current: $I_p/I_N = 0.7$
- Time multiplier: $T_p = 0.05$

Station B:

The relay in B has a primary protection function for line B-C and a backup function for the relay in C. The maximum through-fault current of 1.395 A becomes effective for a fault in location F_2.
For the relay in C, we obtain an operating time of 0.11 s ($I/I_p = 19.93$).

We assume that no special requirements for short operating times exist and can therefore choose an average time grading interval of 0.3 s. The operating time of the relay in B can then be calculated.

- $t_B = 0.11 + 0.3 = 0.41$ s
- Value of $I_p/I_N = \frac{1395\,A}{220\,A} = 6.34$ (see Fig. 2/83)
- With the operating time 0.41 s and $I_p/I_N = 6.34$, we can now derive $T_p = 0.11$ from Fig. 2/84.

*) I_{SCC}max = Maximum short-circuit current
**) I_p/I_N = Relay current multiplier setting
***) I_{prim} = Primary setting current corresponding to I_p/I_N

The setting values for the relay at station B are:

- Pickup current: $I_p/I_N = 1.1$
- Time multiplier $T_p = 0.11$

Given these settings, we can also check the operating time of the relay in B for a close-in fault in F_3: The short-circuit current increases in this case to 2690 A (see Fig. 2/83).
The corresponding I/I_p value is 12.23.

- With this value and the set value of $T_p = 0.11$ we obtain again an operating time of 0.3 s (see Fig. 2/84).

Station A:

- We add the time grading interval of 0.3 s and find the desired operating time $t_A = 0.3 + 0.3 = 0.6$ s.

Following the same procedure as for the relay in station B, we obtain the following values for the relay in station A:

- Pickup current: $I_p/I_N = 1.0$
- Time multiplier $T_p = 0.17$
- For the close-in fault at location F_4 we obtain an operating time of 0.48 s.

Normal inverse

$$t = \frac{0.14}{\left(I/I_p\right)^{0.02} - 1} \cdot T_p(s)$$

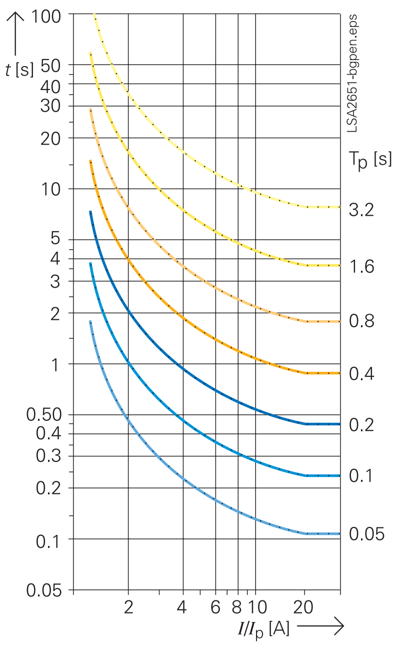


Fig. 2/84
Normal inverse-time characteristic of the 7SJ60 relay

The normal way

To prove the selectivity over the whole range of possible short-circuit currents, it is normal practice to draw the set of operating curves in a common diagram with double log scales. These diagrams can be calculated manually and drawn point-by-point or constructed by using templates.

Today, computer programs are also available for this purpose. Fig. 2/85 shows the relay coordination diagram for the example selected, as calculated by the Siemens program SIGRADE (Siemens Grading Program). For further information please see:
http://www.siemens.com/systemplanning

Note:

To simplify calculations, only inverse-time characteristics have been used for this example. About 0.1 s shorter operating times could have been reached for high-current faults by additionally applying the instantaneous zones *I*>> of the 7SJ60 relays.

Coordination of o/c relays with fuses and low-voltage trip devices

The procedure is similar to the above-described grading of o/c relays. A time interval between 0.1 and 0.2 seconds is usually sufficient for a safe time coordination.

Very and extremely inverse characteristics are often more suitable than normal inverse characteristics in this case. Fig. 2/86 shows typical examples.

Simple distribution grid stations use a power fuse on the secondary side of the supply transformers (Fig. 2/86a).

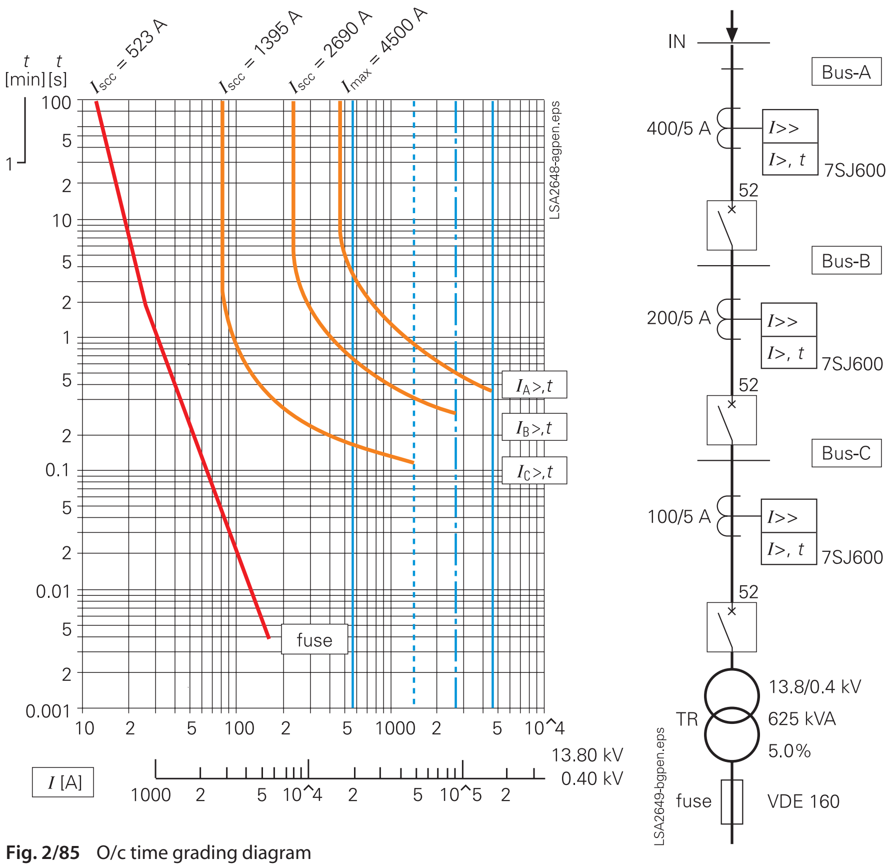
In this case, the operating characteristic of the o/c relay at the infeed has to be coordinated with the fuse curve.

Very inverse characteristics may be used with expulsion-type fuses (fuse cutouts) while extremely inverse versions adapt better to current limiting fuses.

In any case, the final decision should be made by plotting the curves in the log-log coordination diagram.

Electronic trip devices of LV breakers have long-delay, short-delay and instantaneous zones. Numerical o/c relays with one inverse-time and two definite-time zones can closely be adapted to this (Fig. 2/86b).

Protection Coordination



Setting range	Setting
I_p = 0.10 - 4.00 I_N	I_p = 1.0 I_N
T_p = 0.05 - 3.2 s	T_p = 0.17 s
I>> = 0.1 - 25 I_N	I>> = ∞
I_p = 0.10 - 4.00 I_N	I_p = 1.0 I_N
T_p = 0.05 - 3.2 s	T_p = 0.11 s
I>> = 0.1 - 25 I_N	I>> = ∞
I_p = 0.10 - 4.00 I_N	I_p = 0.7 I_N
T_p = 0.05 - 3.2 s	T_p = 0.05 s
I>> = 0.1 - 25 I_N	I>> = ∞
HRC fuse 160 A	

Fig. 2/85 O/c time grading diagram

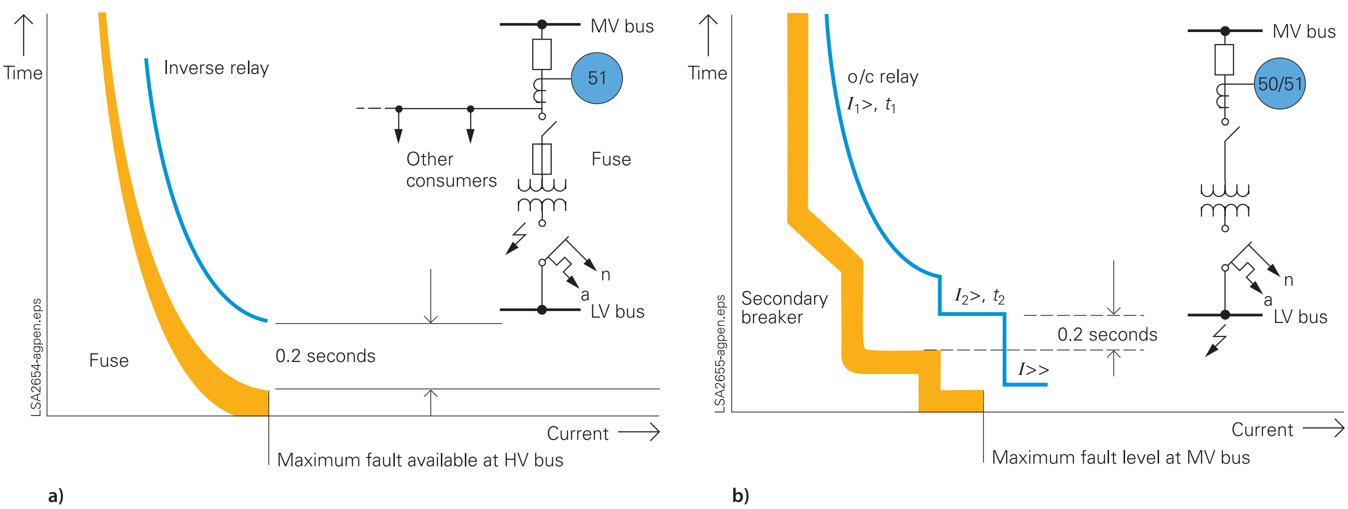


Fig. 2/86
Coordination of an o/c relay with an MV fuse and low-voltage breaker trip device

$Z_{1A} = 0.85 \cdot ZL_{A\text{-}B}$
$Z_{2A} = 0.85 \cdot (ZL_{A\text{-}B} + Z_{1B})$
$Z_{2A} = 0.85 \cdot (ZL_{A\text{-}B} + Z_{2B})$

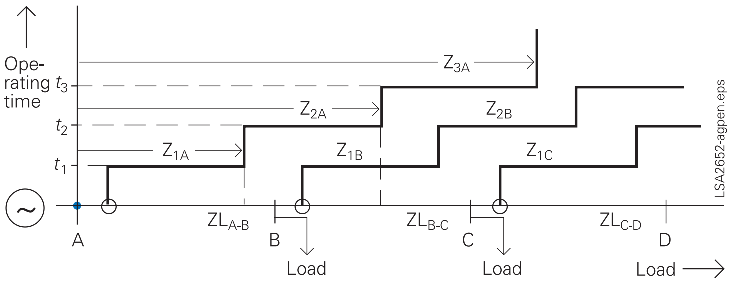


Fig. 2/87 Grading of distance zones

Coordination of distance relays

The distance relay setting must take into account the limited relay accuracy including transient overreach (5 % according to IEC 60255-6), the CT error (1 % for class 5P and 3 % for class 10P) and a security margin of about 5 %. Further, the line parameters are often only calculated, not measured. This is a further source of errors. A setting of 80-85 % is therefore common practice; 80 % is used for mechanical relays while 85 % can be used for the more accurate numerical relays.

Where measured line or cable impedances are available, the protected zone setting may be extended to 90 %. The second and third zones have to keep a safety margin of about 15 to 20 % to the corresponding zones of the following lines. The shortest following line has always to be considered (Fig. 2/87).

As a general rule, the second zone should at least reach 20 % over the next station to ensure backup for busbar faults, and the third zone should cover the longest following line as backup for the line protection.

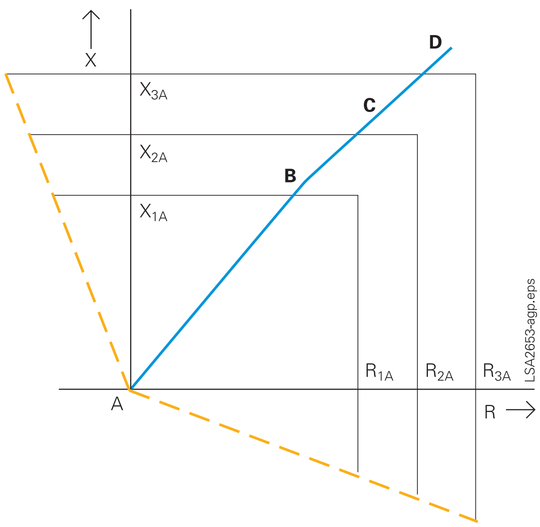


Fig. 2/88
Operating characteristics of Siemens distance relays

Grading of zone times

The first zone normally operates undelayed. For the grading of the time delays of the second and third zones, the same rules as for o/c relays apply (see Fig. 2/82).

For the quadrilateral characteristics (relays 7SA6 and 7SA5) only the reactance values (X values) have to be considered for the protected zone setting. The setting of the *R* values should cover the line resistance and possible arc or fault resistances. The arc resistance can be roughly estimated as follows:

$$R_{\text{Arc}} = \frac{2.5 \cdot l_{\text{arc}}}{I_{\text{SCC Min}}} [\Omega]$$

l_{arc} = arc length in mm

$I_{\text{SCC Min}}$ = minimum short-circuit current in kA

- Typical settings of the ratio R/X are:

– Short lines and cables (≤ 10 km): R/X = 2 to 6
– Medium line lengths < 25 km: R/X = 2
– Longer lines 25 to 50 km: R/X = 1

Shortest feeder protectable by distance relays

The shortest feeder that can be protected by underreaching distance zones without the need for signaling links depends on the shortest settable relay reactance.

$$X_{\text{Prim Min}} = X_{\text{Relay Min}} \cdot \frac{VT_{\text{ratio}}}{CT_{\text{ratio}}}$$

$$l_{\text{min}} = \frac{X_{\text{Prim Min}}}{X'_{\text{Line}}}$$

The shortest setting of the numerical Siemens relays is 0.05 Ω for 1 A relays, corresponding to 0.01 Ω for 5 A relays.

This allows distance protection of distribution cables down to the range of some 500 meters.

Protection Coordination

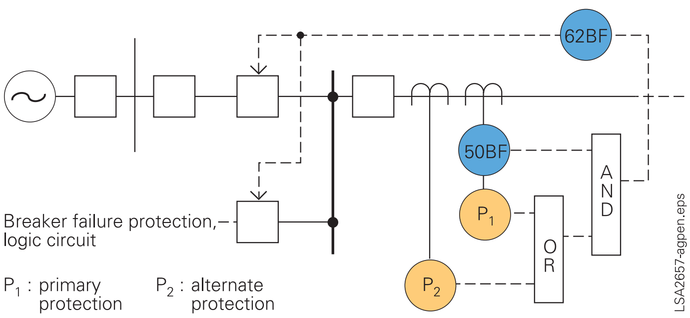


Fig. 2/89
Breaker failure logic

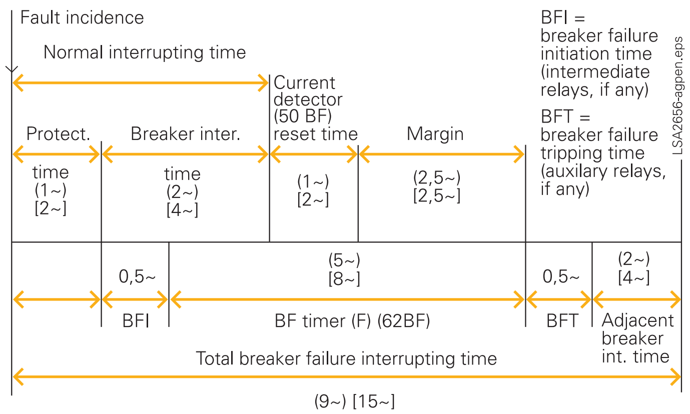


Fig. 2/90
Time coordination of BF time setting

Breaker failure protection setting

Most numerical relays in this guide provide breaker failure (BF) protection as an integral function. The initiation of the BF protection by the internal protection functions then takes place via software logic. However, the BF protection function may also be initiated from external via binary inputs by an alternate protection. In this case the operating time of intermediate relays (BFI time) may have to be considered. Finally, the tripping of the infeeding breakers requires auxiliary relays which add a small time delay (BFI) to the overall fault clearing time. This is in particular the case with 1½-breaker or ring bus arrangements where a separate breaker failure relay (7SV600 or 7VK61) is used per breaker (see application example **15**).

The decisive criterion of BF protection time coordination is the reset time of the current detector (50BF) which must not be exceeded under any condition during normal current interruption. The reset times specified in the Siemens numerical relay manuals are valid for the worst-case condition: interruption of a fully offset short-circuit current and low current pickup setting (0.1 to 0.2 times rated CT current).

The reset time is 1 cycle for EHV relays (7SA6/52, 7VK61) and 1.5 to 2 cycles for distribution type relays (7SJ***).

Fig. 2/90 shows the time chart for a typical breaker failure protection scheme. The stated times in parentheses apply for transmission system protection and the times in square brackets for distribution system protection.

High-impedance differential protection: Verification of design

The following design data must be established:

CT data

The CTs must all have the same ratio and should be of low leakage flux design according to Class TPS of IEC 60044-6 (Class X of BS 3938). The excitation characteristic and the secondary winding resistance are to be provided by the manufacturer.
The knee-point voltage of the CT must be at least twice the relay pickup voltage to assure dependable operation with internal faults.

Differential relay
The differential relay must be a high-impedance relay designed as sensitive current relay (7VH60: 20 mA) with series resistor. If the series resistor is integrated in the relay, the setting values may be directly applied in volts, as with the relay 7VH60 (6 to 60 V or 24 to 240 V)

Sensitivity
For the relay to operate in case of an internal fault, the primary current must reach a minimum value to supply the relay pickup current (I_R), the varistor leakage current (I_{var}) and the magnetizing currents of all parallel-connected CTs at the set pickup voltage. Low relay voltage setting and CTs with low magnetizing current therefore increase the protection sensitivity.

Stability during external faults
This check is made by assuming an external fault with maximum through-fault current and full saturation of the CT in the faulted feeder. The saturated CT is then substituted with its secondary winding resistance R_{CT} and the appearing relay voltage V_R corresponds to the voltage drop of the infeeding currents (through-fault current) across R_{CT} and R_{lead}. The current (voltage) at the relay must, under this condition, stay reliably below the relay pickup value.

In practice, the wiring resistances R_{lead} may not be equal. In this case, the worst condition with the highest relay voltage (corresponding to the highest through fault current) must be sought by considering all possible external feeder faults.

Setting

The setting is always a trade-off between sensitivity and stability. A higher voltage setting leads not only to enhanced through-fault stability, but also to higher CT magnetizing and varistor leakage currents resulting consequently in a higher primary pickup current.

A higher voltage setting also requires a higher knee-point voltage of the CTs and therefore greater size of the CTs.

A sensitivity of 10 to 20 % I_N is normal for motor and transformer differential protection, or for restricted earth-fault protection.

With busbar protection a pickup value ≥ I_N is normally applied.

An increased pickup current value can be achieved by connecting a shunt resistor (as an option) in parallel to the relay.

Varistor

Voltage limitation by a varistor is needed if peak voltages near or above the insulation voltage (2 kV) are expected. A limitation to 1500 V_{rms} is then recommended.

This can be checked for the maximum internal fault current by applying the formula shown for $V_{R\,max.}$

A restricted earth-fault protection may sometimes not require a varistor but a busbar protection in general does.

The electrical varistor characteristic can be expressed as $V = K \cdot I^B$ where K and B are the varistor constants.

Relay setting V_{rms}	K	B	Varistor type
≤ 125	450	0.25	600 A /S1/S256
125 – 240	900	0.25	600 A /S1/S1088

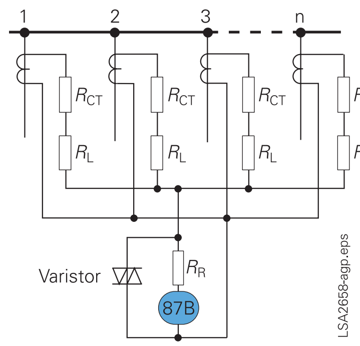
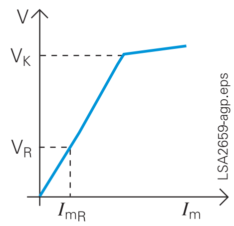


Fig. 2/91
Principal connection diagram



V_K = CT knee-point voltage

$V_R = R_R \cdot I_R$

$V_K = \geq 2 \cdot V_R$

Sensitivity:

$I_{Fmin} = N \cdot (I_R + I_{Var} + n \cdot I_{mR})$

Stability:

$$I_{F\,max.\,Through} < N \cdot \frac{R_R}{R_{lead} + R_{CT}} \cdot I_R$$

N	= CT ratio
I_R	= Set relay pickup current
I_{Var}	= Varistor spill current
I_{mR}	= CT magnetizing current at relay pickup voltage

Voltage limitation by a varistor is required if:

$$V_{Rmax} = 2\sqrt{2V_K\left(V_F - V_K\right)} > 1.5\text{ kV}$$

$$\text{with } V_F \quad \frac{I_{F\,max\,Through}}{N}\left(R_{CT} + 2 \cdot R_{lead} + R_R\right)$$

Calculation example:

Given:	n	= 8 feeders
	N	= 600/1 A
	V_K	= 500 V
	R_{CT}	= 4 Ω
	I_{mR}	= 30 mA (at relay setpoint)
	R_{lead}	= 3 Ω
	I_R	= 20 mA
	R_R	= 10 kΩ
	I_{Var}	= 11 mA (at relay setpoint)

Sensitivity

$I_{Fmin} = N \cdot (I_R + I_{Var} + n \cdot I_{mR})$

$$I_{Fmin} = \frac{600}{1} \cdot (0.02 + 0.05 + 8 \text{ x } 0.03)$$

I_{Fmin} = 186 A (31 % I_N)

Stability:

$$I_{F\,max\,Through} < N \cdot \frac{R_R}{R_{lead} + R_{CT}} \cdot I_R$$

$$I_{F\,max\,Through} < \frac{600}{1} \cdot \frac{10{,}000}{3 + 4} \cdot 0.02$$

$I_{F\,max\,Through}$ < 17 kA (28 x I_N)

Protection Coordination

Instrument transformers

Instrument transformers

Instrument transformers must comply with the applicable IEC recommendations IEC 60044, formerly IEC 60185 (CT) and 60186 (PT), ANSI/IEEE C57.13 or other comparable standards.

Potential transformers

Potential transformers (PT) in single or double-pole design for all primary voltages have typical single or dual secondary windings of 100, 110 or 115 V/$\sqrt{3}$ with output ratings between 10 and 300 VA, and accuracies of 0.2, 0.5 or 1 % to suit the particular application. Primary BIL values are selected to match those of the associated switchgear.

Current transformers

Current transformers (CT) are usually of the single-ratio type with wound or bar-type primaries of adequate thermal rating. Single, dual or triple secondary windings of 1 or 5 A are standard. 1 A rating should however be preferred, particularly in HV and EHV stations, to reduce the burden of the connected lines. Output power (rated burden in VA), accuracy and saturation characteristics (rated symmetrical short-circuit current limiting factor) of the cores and secondary windings must meet the particular application.

The CT classification code of IEC is used in the following:

Measuring cores

These are normally specified with 0.5 % or 1.0 % accuracy (class 0.5 FS or 1.0 FS), and an rated symmetrical short-circuit current limiting factor of 5 or 10.

The required output power (rated burden) should be higher than the actually connected burden. Typical values are 5, 10, 15 VA. Higher values are normally not necessary when only electronic meters and recorders are connected.

A typical specification could be: 0.5 FS 10, 15 VA.

Cores for billing values metering

In this case, class 0.2 FS is normally required.

Protection cores

The size of the protection core depends mainly on the maximum short-circuit current and the total burden (internal CT burden, plus burden of connected lines plus relay burden).

Furthermore, a transient dimensioning factor has to be considered to cover the influence of the DC component in the short-circuit current.

In general, an accuracy of 1 % in the range of 1 to 2 times nominal current (class 5 P) is specified. The rated symmetrical short-circuit current factor K_{ssc} should normally be selected so that at least the maximum short-circuit current can be transmitted without saturation (DC component not considered).

This results, as a rule, in rated symmetrical short-circuit current factors of 10 or 20 depending on the rated burden of the CT in relation to the connected burden. A typical specification for protection cores for distribution feeders is 5P10, 10 VA or 5P20, 5 VA.

The requirements for protective current transformers for transient performance are specified in IEC 60044-6.

In many practical cases, iron-core CTs cannot be designed to avoid saturation under all circumstances because of cost and space reasons, particularly with metal-enclosed switchgear.

The Siemens relays are therefore designed to tolerate CT saturation to a large extent. The numerical relays proposed in this guide are particularly stable in this case due to their integrated saturation detection function.

Glossary of used abbreviations
(according to IEC 60044-6, as defined)

K_{ssc}	= rated symmetrical short-circuit current factor (example: CT cl. 5P20 → K_{SSC} = 20)
K'_{ssc}	= effective symmetrical short-circuit current factor
K_{td}	= transient dimensioning factor
$I_{ssc\,max}$	= maximum symmetrical short-circuit current
I_{pn}	= CT rated primary current
I_{sn}	= CT rated secondary current
R_{ct}	= secondary winding d.c. resistance at 75°C (or other specified temperature)
R_b	= rated resistive burden
$R'_b = R_{lead} + R_{relay}$	= connected resistive burden
T_P	= primary time constant (net time constant)
V_K	= kneepoint voltage (r.m.s.)
R_{relay}	= relay burden
R_{lead}	$= \dfrac{2 \cdot \rho \cdot l}{A}$

with
1 = single conductor length from CT to relay in m
ρ = specific resistance = 0.0175 Ω mm²/m (copper wires) at 20 °C (or other specified temperature)
A = conductor cross-section in mm²

CT dimensioning formulae

$$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b} \text{ (effective)}$$

$$\text{with } K'_{ssc} \geq K_{td} \cdot \frac{I_{SCC\,max}}{I_{pn}} \text{ (required)}$$

The effective symmetrical short-circuit current factor K'_{ssc} can be calculated as shown in the table above.

The rated transient dimensioning factor K_{td} depends on the type of relay and the primary DC time constant. For relays with a required saturation free time from ≤ 0.4 cycle, the primary (DC) time constant T_P has only little influence.

CT design according to BS 3938/IEC 60044-1 (2000)

The design values according to IEC 60044 can be approximately transfered into the BS standard definition by following formula:

$$V_K = \frac{(R_b + R_{ct}) \cdot I_{sn} \cdot K_{ssc}}{1.3}$$

Example:
IEC 60044: 600/1, 5P10, 15 VA, $R_{ct} = 4\ \Omega$

$$\text{IEC PX or BS: } V_K = \frac{(15 + 4) \cdot 1 \cdot 10}{1.3} \text{ V} = 146 \text{ V}$$

$$R_{ct} = 4\ \Omega$$

For *CT design according to ANSI/IEEE C 57.13* please refer to page 2/56

Table 2/1 CT requirements

Relay type	Transient dimensioning factor K_{td}	Min. required sym. short-circuit current factor K'ssc	Min. required kneepoint voltage V_K
Overcurrent-time protection 7SJ511, 512, 531 7SJ45, 46, 60 7SJ61, 62, 63, 64	–	$K'_{ssc} \geq \frac{I_{High\ set\ point}}{I_{pn}}$ at least: 20	$V_K \geq \frac{I_{High\ set\ point}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ at least: $\frac{20}{1.3} \cdot (R_{ct} + R'_b) \cdot I_{sn}$
Line differential protection (pilot wire) 7SD600	–	$K'_{ssc} \geq \frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}}$ and: $\frac{3}{4} \leq \frac{(K'_{ssc} \cdot I_{pn})_{end1}}{(K'_{ssc} \cdot I_{pn})_{end2}} \leq \frac{4}{3}$	$V_K \geq \frac{I_{scc\ max\ (ext.\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and: $\frac{3}{4} \leq \frac{(V_K \cdot I_{pn} / I_{sn})_{end1}}{(V_K \cdot I_{pn} / I_{sn})_{end2}} \leq \frac{4}{3}$
Line differential protection (without distance function) 7SD52x, 53x, 610 (50 Hz) 7SD52x, 53x, 610 (60 Hz)	Transformer / Busbar / Line / Gen. / Motor 1.2 / 1.2 / 1.2 1.6 / 1.6 / 1.6	$K'_{ssc} \geq$ $K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{I_{pn}}$	$V_K \geq$ $K_{td} \cdot \frac{I_{scc\ max\ (ext.\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$
Transformer / Generator differential protection 7UT612 7UT613, 633, 635 7UM62	Transformer / Busbar / Line / Gen. / Motor 4 / 4 / 5 3 / 3 / 5 4 / – / 5	and (only for 7SS): $K'_{ssc} \leq 100$ (measuring range)	and (only for 7SS): $V_K \leq \frac{100}{1.3} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ (measuring range)
Busbar protection 7SS5, 7SS600	for stabilizing factors k ≥ 0.5 0.5		
Distance protection 7SA522, 7SA6, 7SD5xx*) *) with distance function	primary DC time constant T_P [ms] ≤ 30 / ≤ 50 / ≤ 100 / ≤ 200 K_{td} (a): 1 / 2 / 4 / 4 K_{td} (b): 4 / 5 / 5 / 5	$K'_{ssc} \geq$ $K_{td}(a) \cdot \frac{I_{scc\ max\ (close-in\ fault)}}{I_{pn}}$ and: $K_{td}(b) \cdot \frac{I_{scc\ max\ (zone\ 1-end\ fault)}}{I_{pn}}$	$V_K \geq$ $K_{td}(a) \cdot \frac{I_{scc\ max\ (close-in\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ and: $K_{td}(b) \cdot \frac{I_{scc\ max\ (zone\ 1-end\ fault)}}{1.3 \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$

Protection Coordination

The CT requirements mentioned in Table 2/1 on page 2/53 are simplified in order to allow fast CT calculations on the safe side. More accurate dimensioning can be done by more intensive calculation with Siemens' CTDIM (V 3.21) program. Results of CTDIM are released by the relay manufacturer.

Adaption factor for 7UT6, 7UM62 relays (limited resolution of measurement)

(also 7SD52, 53, 610, when transformer inside protected zone)

$$F_{\text{Adap}} = \frac{I_{\text{pn}}}{I_{\text{nO}}} \cdot \frac{I_{\text{Nrelay}}}{I_{\text{sn}}} = \frac{I_{\text{pn}} \cdot \sqrt{3} \cdot V_{\text{nO}}}{S_{\text{Nmax}}} \cdot \frac{I_{\text{Nrelay}}}{I_{\text{sn}}} \rightarrow \text{Request} : 1/8 \leq F_{\text{Adap}} \leq 8$$

with

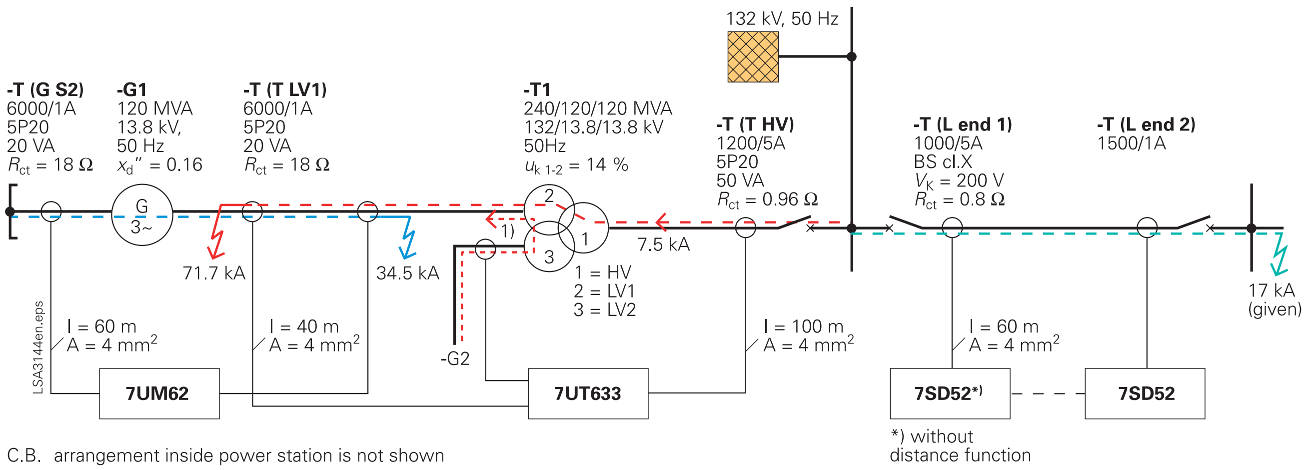
I_{nO} = rated current of the protected object
V_{nO} = rated voltage of the protected object
I_{Nrelay} = rated current of the relay
$S_{\text{N max}}$ = maximum load of the protected object (for transformers: winding with max. load)

Attention: when low impedance REF is used, the request for the REF side (3-phase) is:
$1/4 \leq F_{\text{Adap}} \leq 4$, (for the neutral CT: $1/8 \leq F_{\text{Adap}} \leq 8$

Further condition for 7SD52x, 53x, 610 relays
(when used as line differential protection without transformer inside protected zone)
Maximum ratio between primary currents of CTs at the end of the protected line:

$$\frac{I_{\text{pn max}}}{I_{\text{pn min}}} \leq 8$$

Example 1: CT verification for 7UM62, 7UT6, 7SD52 (7SD53, 7SD610)



C.B. arrangement inside power station is not shown
x_d'' = Generator direct axis subtransient reactance in p.u.
$u_{k\ 1\text{-}2}$ = Transformer impedance voltage HV side – LV side 1 in %
R_{relay} = Assumed with 0.1 Ω, (power consumption for above relays is below 0.1 VA)

1) Current from side 3 is due to $u_{k\ 2\text{-}3}$ and x''_d of Gen. 2 in most cases negligible

Fig. 2/92

Example 1 (continued)
Verification of the numerical differential protection

-T (G S2), 7UM62	-T (T LV1), 7UT633	-T (T HV), 7UT633	-T (L end 1), 7SD52
$I_{scc\,max\,(ext.\,fault)} = \frac{c \cdot S_{NG}}{\sqrt{3} \cdot V_{NG} \cdot x_d''}$ $= \frac{1.1 \cdot 120000\text{ kVA}}{\sqrt{3} \cdot 13.8\text{ kV} \cdot 0.16} = 34516\text{ A}$	$I_{scc\,max\,(ext.\,fault)} = \frac{S_{NT}}{\sqrt{3} \cdot V_{NT} \cdot u_k}$ $= \frac{240000\text{ kVA}}{\sqrt{3} \cdot 13.8\text{ kV} \cdot 0.14} = 71721\text{ A}$	$I_{scc\,max\,(ext.\,fault)} = \frac{S_{NT}}{\sqrt{3} \cdot V_{NT} \cdot u_k}$ $= \frac{240000\text{ kVA}}{\sqrt{3} \cdot 132\text{ kV} \cdot 0.14} = 7498\text{ A}$	$I_{scc\,max\,(ext.\,fault)} = 17\text{ kA}$ (given)
$K_{td} = 5$ (from Table 2/1)	$K_{td} = 3$ (from Table 2/1)	$K_{td} = 3$ (from Table 2/1)	$K_{td} = 1.2$ (from Table 2/1)
$K'_{ssc} \geq K_{td} \cdot \frac{I_{scc\,max\,(ext.\,fault)}}{I_{pn}}$ $= 5 \cdot \frac{31378\text{ A}}{6000\text{ A}} = 28.8$	$K'_{ssc} \geq K_{td} \cdot \frac{I_{scc\,max\,(ext.\,fault)}}{I_{pn}}$ $= 3 \cdot \frac{71721\text{ A}}{6000\text{ A}} = 35.9$	$K'_{ssc} \geq K_{td} \cdot \frac{I_{scc\,max\,(ext.\,fault)}}{I_{pn}}$ $= 3 \cdot \frac{7498\text{ A}}{1200\text{ A}} = 18.7$	
$R_b = \frac{S_n}{I^2_{sn}} = \frac{20\text{ VA}}{1\text{ A}^2} = 20\ \Omega$	$R_b = \frac{S_n}{I^2_{sn}} = \frac{20\text{ VA}}{1\text{ A}^2} = 20\ \Omega$	$R_b = \frac{S_n}{I^2_{sn}} = \frac{50\text{ VA}}{5\text{ A}^2} = 2\ \Omega$	
$R'_b = R_{lead} + R_{relay}$ $= \frac{2 \cdot \rho \cdot l}{A} + 0.1\ \Omega$ $= \frac{2 \cdot 0.0175\ \frac{\Omega\text{ mm}^2}{\text{m}} \cdot 60\text{ m}}{4\text{ mm}^2}$ $+ 0.1\ \Omega$ $= 0.625\ \Omega$	$R'_b = R_{lead} + R_{relay}$ $= \frac{2 \cdot \rho \cdot l}{A} + 0.1\ \Omega$ $= \frac{2 \cdot 0.0175\ \frac{\Omega\text{ mm}^2}{\text{m}} \cdot 40\text{ m}}{4\text{ mm}^2}$ $+ 0.1\ \Omega$ $= 0.450\ \Omega$	$R'_b = R_{lead} + R_{relay}$ $= \frac{2 \cdot \rho \cdot l}{A} + 0.1\ \Omega$ $= \frac{2 \cdot 0.0175\ \frac{\Omega\text{ mm}^2}{\text{m}} \cdot 100\text{ m}}{4\text{ mm}^2}$ $+ 0.1\ \Omega$ $= 0.975\ \Omega$	$R'_b = R_{lead} + R_{relay}$ $= \frac{2 \cdot \rho \cdot l}{A} + 0.1\ \Omega$ $= \frac{2 \cdot 0.0175\ \frac{\Omega\text{ mm}^2}{\text{m}} \cdot 60\text{ m}}{4\text{ mm}^2}$ $+ 0.1\ \Omega$ $= 0.625\ \Omega$
$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{18\ \Omega + 20\ \Omega}{18\ \Omega + 0.625\ \Omega} = 40.8$	$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{18\ \Omega + 20\ \Omega}{18\ \Omega + 0.450\ \Omega} = 41.2$	$K'_{ssc} = K_{ssc} \cdot \frac{R_{ct} + R_b}{R_{ct} + R'_b}$ $= 20 \cdot \frac{0.96\ \Omega + 2\ \Omega}{0.96\ \Omega + 0.975\ \Omega} = 30.6$	$V_K \geq K_{td} \cdot \frac{I_{scc\,max\,(ext.\,fault)}}{\mathbf{1.3} \cdot I_{pn}} \cdot (R_{ct} + R'_b) \cdot I_{sn}$ $= 1.2 \cdot \frac{17000\text{ A}}{1.3 \cdot 1000\text{ A}} \cdot (0.8\ \Omega + 0.625\ \Omega) \cdot 5\text{ A}$ $= 111.8\text{ V}$
K'_{ssc} required = 28.8, K'_{ssc} effective = 40.8 28.8 < 40.8 → CT dimensioning is ok	K'_{ssc} required = 35.9, K'_{ssc} effective = 41.2 35.9 < 41.2 → CT dimensioning is ok	K'_{ssc} required = 18.7, K'_{ssc} effective = 30.6 18.7 < 30.6 → CT dimensioning is ok	V_K required = 111.8 V, V_K effective = 200 V 111.8 V < 200 V → CT dimensioning is ok
$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot V_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{6000\text{ A} \cdot \sqrt{3} \cdot 13.8\text{ kV}}{120000\text{ kVA}} \cdot \frac{1\text{ A}}{1\text{ A}}$ $= 1.195$ $1/8 \leq 1.195 \leq 8$ → ok!	$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot V_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{6000\text{ A} \cdot \sqrt{3} \cdot 13.8\text{ kV}}{240000\text{ kVA}} \cdot \frac{1\text{ A}}{1\text{ A}}$ $= 0.598$ $1/8 \leq 0.598 \leq 8$ → ok!	$F_{Adap} = \frac{I_{pn} \cdot \sqrt{3} \cdot V_{nO}}{S_{Nmax}} \cdot \frac{I_{Nrelay}}{I_{sn}}$ $= \frac{1200\text{ A} \cdot \sqrt{3} \cdot 132\text{ kV}}{240000\text{ kVA}} \cdot \frac{5\text{ A}}{5\text{ A}}$ $= 1.143$ $1/8 \leq 1.143 \leq 8$ → ok!	$\frac{I_{pn\,max}}{I_{pn\,min}} \leq 8$ $\frac{1500\text{ A}}{1000\text{ A}} = 1.5 \leq 8$ → ok!

Protection Coordination

Example 2:
Stability-verification of the numerical busbar protection relay 7SS52

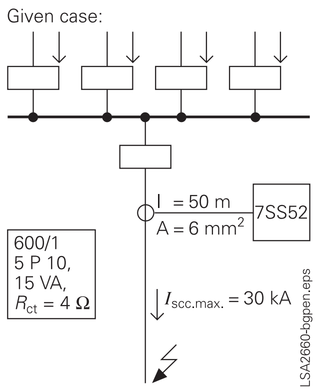


Fig. 2/93

$\dfrac{I_{SCC.max.}}{I_{pn}}$	$= \dfrac{30{,}000\ A}{600\ A} = 50$

According to table 2/1 on page 2/53 K_{td} = ½)

K'_{ssc}	$\geq \dfrac{1}{2} \cdot 50 = 25$
R_b	$= \dfrac{15\ VA}{1\ A^2} = 15\ \Omega$
R_{relay}	$= 0.1\ \Omega$
R_{lead}	$= \dfrac{2 \cdot 0.0175 \cdot 50}{6} = 0.3\ \Omega$
R'_b	$= R_l + R_{relay} = 0.3\ \Omega + 0.1\ \Omega = 0.4\ \Omega$
K'_{ssc}	$= \dfrac{R_{ct} + R_b}{R_{ct} + R'_b} \cdot K_{ssc} = \dfrac{4\ \Omega + 15\ \Omega}{4\ \Omega + 0.4\ \Omega} \cdot 10 = 43.2$

Result:

The effective K'_{ssc} is 43.2, the required K'_{ssc} is 25. Therefore the stability criterion is fulfilled.

Relay burden

The CT burdens of the numerical relays of Siemens are below 0.1 VA and can therefore be neglected for a practical estimation. Exceptions are the busbar protection 7SS60 and the pilot-wire relays 7SD600.

Intermediate CTs are normally no longer necessary as the ratio adaptation for busbar and transformer protection is numerically performed in the relay.

Analog static relays in general have burdens below about 1 VA.

Mechanical relays, however, have a much higher burden, up to the order of 10 VA.

This has to be considered when older relays are connected to the same CT circuit.

In any case, the relevant relay manuals should always be consulted for the actual burden values.

Burden of the connection leads

The resistance of the current loop from the CT to the relay has to be considered:

R_{lead}	$= \dfrac{2 \cdot \rho \cdot l}{A}$
l	= single conductor length from the CT to the relay in m.
Specific resistance: ρ	$= 0.0175 \dfrac{\Omega \cdot mm^2}{m}$ (copper wires) at 20 °C
A	= conductor cross-section in mm²

CT design according to ANSI/IEEE C 57.13

Class C of this standard defines the CT by ist secondary terminal voltage at 20 times rated current, for which the ratio error shall not exceed 10 %. Standard classes are C100, C200, C400 and C800 for 5 A rated secondary current.

This terminal voltage can be approximately calculated from the IEC data as follows:

ANSI CT definition

$V_{s.t.max}$	$= 20 \cdot 5\ A \cdot R_b \cdot \dfrac{K_{ssc}}{20}$
with R_b	$= \dfrac{P_b}{I_{sn}^2}$ and $I_{Nsn} = 5\ A$, we get
$V_{s.t.max}$	$= \dfrac{P_b \cdot K_{ssc}}{5\ A}$
Example: IEC 60044:	600/5, 5P20, 25 VA
ANSI C57.13:	$V_{s.t.max} = \dfrac{(25\ VA \cdot 20)}{5\ A} = 100\ V$, acc. to class C100

Operating Programs

Page

DIGSI 4
One Software for all SIPROTEC Protection Relays

LSP2337-afp.tif

Description

DIGSI is a familiar trade name already today. Originally launched as an MS-DOS software, DIGSI, in its third version, was developed to become a convenient tool for setting numerical protection relays under MS Windows. DIGSI 4 now is the logical innovation for easy-to-use and user-friendly setting, commissioning and operation of all SIPROTEC protection relays, whatever the version. With a PC or Notebook, you can set the relays via one of the interfaces and read out and visualize fault data.

Because of its modular design, DIGSI can be used economically depending on the respective requirements. The basic version DIGSI 4 Basis already covers most standard tasks. The basic version can be extended with optional components. The basic version includes:

- Setting parameters and routing
- Human-machine interface
- Commissioning, controlling and testing
- Communication via a direct connection, via PROFIBUS-FMS or other bus systems.

The complete version DIGSI 4 Professional has a greater scope than the basic version with the following additional functions:

- Display Editor – for creating and modifying default and single-line diagrams shown on the display
- SIGRA – for visualizing and evaluating fault records
- DIGSI Remote – for remote controlling of SIPROTEC 4 relays via a modem connection
- CFC – for creating new functionality or for changing the predefined interlock conditions
- IEC 61850 System Configurator – for configuring and parameterizing IEC 61850 stations. This tool allows you to manage subnets, network communicators and their IP addresses and to connect the information items of different communicators.

By the way: If you are already working with the engineering tool SICAM plus TOOLS, you can integrate the functionality of DIGSI 4 seamlessly into the SIMATIC Manager. You can also use DIGSI 4 in conjunction with SICAM on the station control level without any problems.

The CD-ROM contains all components in English, German, Russian, French and Spanish. A “quick start” manual and the cable for direct connection between PC and protection unit is also delivered.

Function overview

- Device administration in projects with freely configurable hierarchies for any substation and electrical power station topology
- Import and export of parameter sets
- Full use of the great flexibility of the PLC (Programmable Logic Controller) without any programming skills
- Modify the default and single-line diagram displays preset in the factory with the Display Editor – just like a conventional image editor
- Precise fault analysis with SIGRA: visualization of fault records in curves over time, circle diagrams, vector diagrams, and bar charts
- Innovative I/O configuration in a clearly structured matrix
- Intelligent plausibility checks rule out incorrect input
- Graphical visualization of characteristics and zone diagrams with direct manipulation of the curves
- Password-protected access for different jobs such as parameter setting, commissioning and controlling (authorized staff only)
- Testing and diagnostic functions – decisive support in the commissioning phase
- Direct operation via serial port, remote operation via modem
- Field bus communication via IEC 61850 protocol IEC 60870-5-103 protocol and PROFIBUS-FMS protocol

Hardware requirements

- Pentium with 800 MHz processor
- 500 Mbyte of free hard disk space
- 128 Mbyte of RAM (256 Mbyte recommended)
- CD-ROM Drive / DVD-ROM Drive
- Pointer device (i.e. mouse)
- Serial port (COM)
- USB port

Software requirements

- MS Windows 2000 / XP Professional Edition

3

Functions

DIGSI 4 Manager – the start platform

When working with DIGSI 4 Basis, you start out from the DIGSI 4 Manager: with this tool, you can conveniently structure and manage projects; freely-configurable hierarchies allow for representing any station topology. The protection relays are simply chosen from a catalog and dragged into the project. Beside the possibility of archiving entire projects, the customer now also can export individual units, e.g. to a floppy disk: time-consuming search within the file system is a thing of the past.

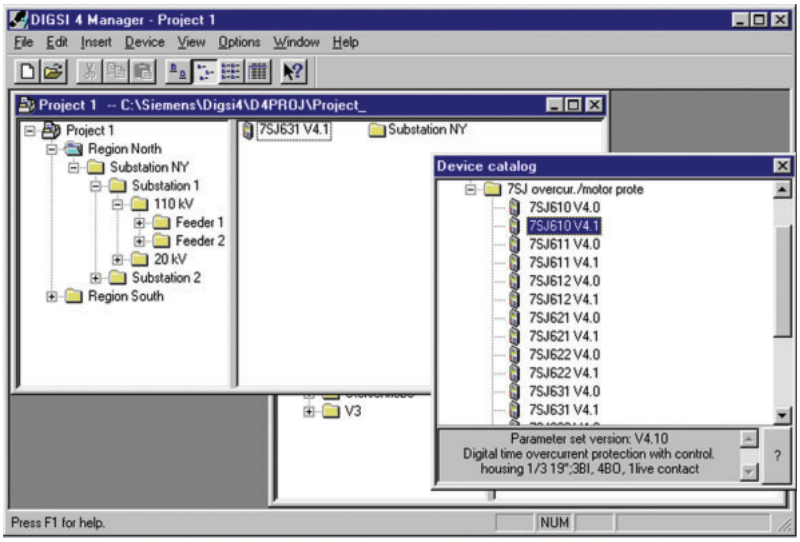
By double-clicking a relay, you will see all the operating features: This gives you direct access to the parameter setting, I/O configuration and – provided that you are online – the commissioning functions and process data. It corresponds exactly to the menu tree implemented in the units; this consistency facilitates mixed operation, in particular during commissioning.

Routing and allocation

While in the previous versions the user had to browse through a series of operational sequences in order to link one single signal to a relay input or output, the allocation matrix is a real innovation in this respect: All items of information are listed in one window sorted according to functions and can be configured very easily and allocated without intermediate steps to the desired I/Os, LEDs, buffers and the system interface, which also appear in this window. Example: If you want a signal to be processed by the PLC or to be displayed dynamically in the default or single-line diagrams, all you have to do is making a “check mark” in the corresponding cell. A wide range of filters plus the possibility to “expand” or “collapse” rows or columns in a flash ensure perfect overview.

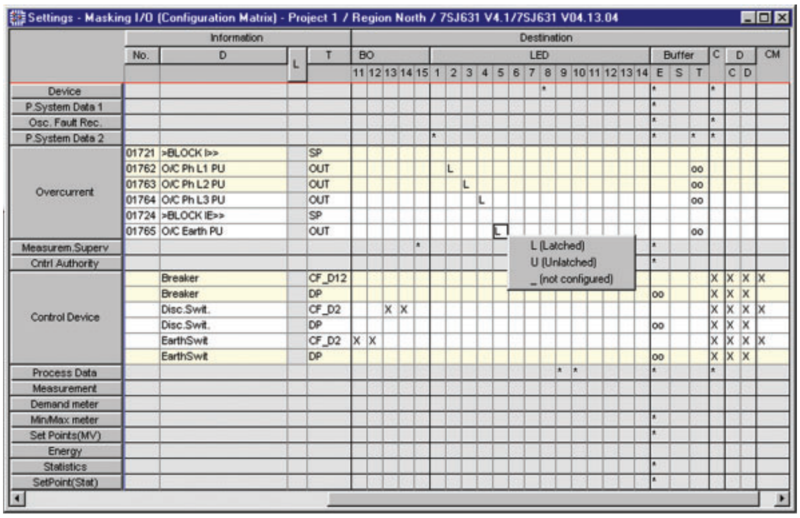
Parameterizing

In the clearly-structured tabbed dialog boxes, only the settings you really need and which are determined by the functional scope are displayed.
Particularly when making the protection relay-specific settings, it may be of advantage to display the tripping characteristics. With just one mouse click in the settings dialog box you can visualize the characteristics or zone diagrams in a window, depending on the set values. This allows you to observe conveniently the effects of any change in the settings.



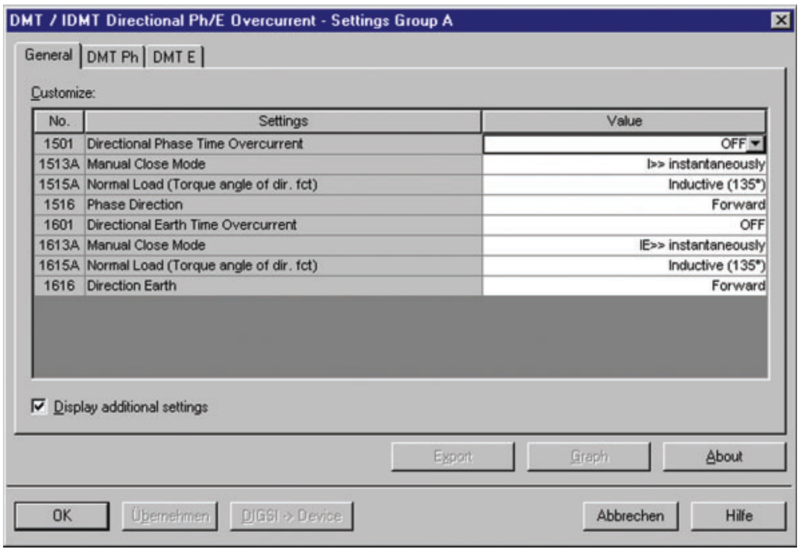
LSP2329-afpen.tif

Fig. 3/1 Easy management of relays in projects



LSP2328-afpen.tif

Fig. 3/2 Routing of indications, measured values and commands in a concise matrix



LSP2326-afpen.tif

Fig. 3/3 Well-structured parameterizing with context-sensitive help

Functions

Test & Diagnosis

The testing and diagnostic functions provide decisive support during the phase of commissioning: you can check quickly and easily the wiring or observe the effect that an indication transmitted via the system interface causes in the higher-level station.

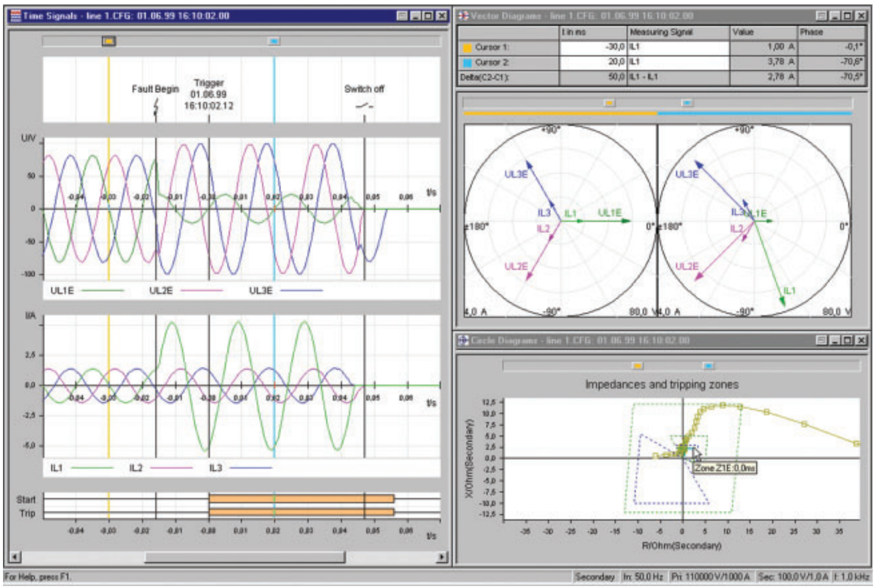
The fault indications which are logged in the relay in the case of a disturbance are listed in DIGSI and can be saved and printed out for documentation purposes.

SIGRA for fault analysis

The integrated Comtrade Viewer 4 allows you to visualize the corresponding measured variables in curves as a function of time. However, if you are looking for a convenient tool which offers a more detailed fault analysis and is able to handle not only curves, but also circle diagrams, vector diagrams and bar charts, then the SIGRA 4 optional package is the right choice. On the basis of the measured values which are registered in the fault record, SIGRA calculates further values such as positive-sequence impedances, r.m.s. values, symmetrical components, vectors, etc. Two measuring cursors enable you to measure the fault record quickly and conveniently. Other fault records, e.g. from the remote end of a line, can be added to the existing fault record. A synchronization function makes it possible to synchronize the fault records to a common time basis.

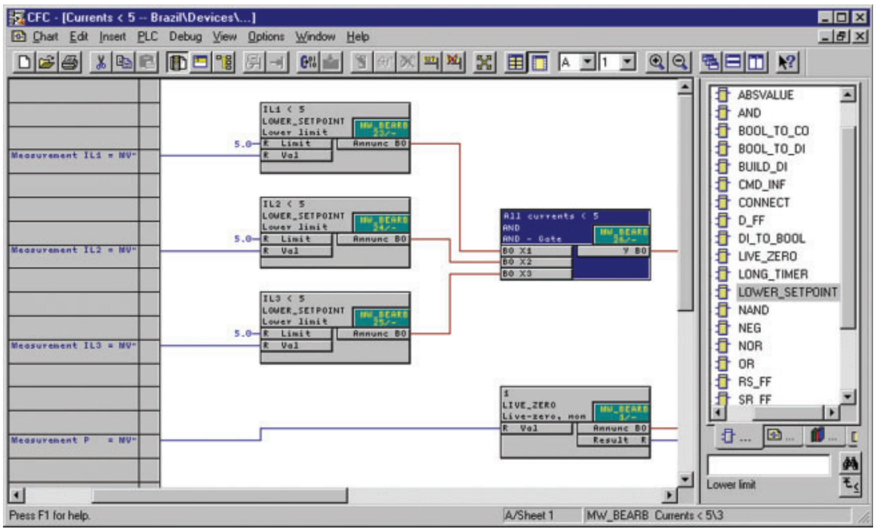
CFC programming

The SIPROTEC 4 devices incorporate a PLC (Programmable Logic Controller), in which factory-preset standard interlockings are executed. If you wish to modify and adapt them, you use the CFC Editor, which is available as a component in DIGSI 4 Professional. Thanks to its fully graphical user interface, even users without programming knowledge are able to make full and flexible use of the PLC's wide range of possibilities. All items of information which have been configured to "CFC" in the allocation matrix before can be "interconnected" with function blocks here. Once installed, the editor familiar from the SIMATIC world presents itself with a SIPROTEC-specific block library, which does not only provide standard operators such as "AND", but also more complex functions such as "TIMER". A sophisticated consistency check ensures error-free configuration and reliable operation of the protection relay functions.



LSP2325-afpen.tif

Fig. 3/4 Exact visualization and evaluation of fault records with SIGRA

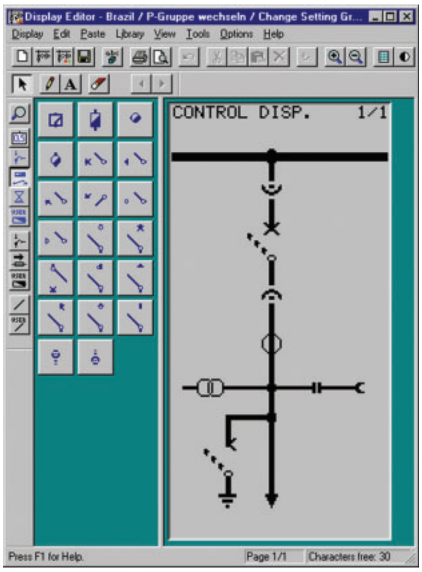


LSP2324-afpen.tif

Fig. 3/5 Fully graphic programming, no programming skills required

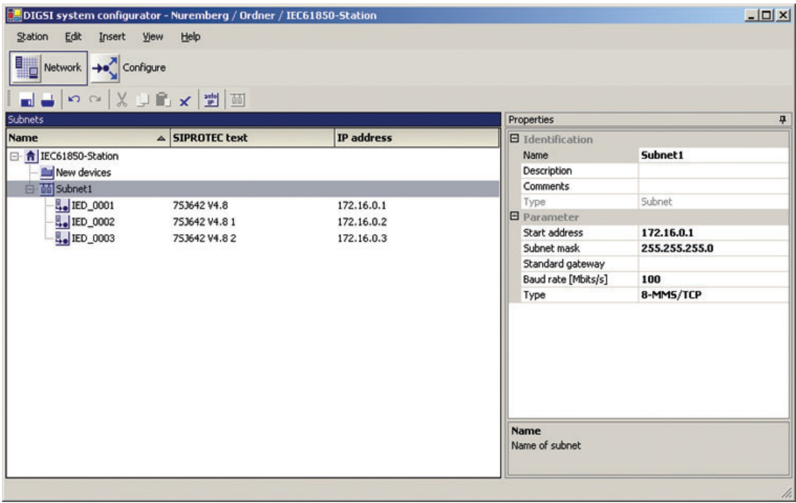
3

Functions



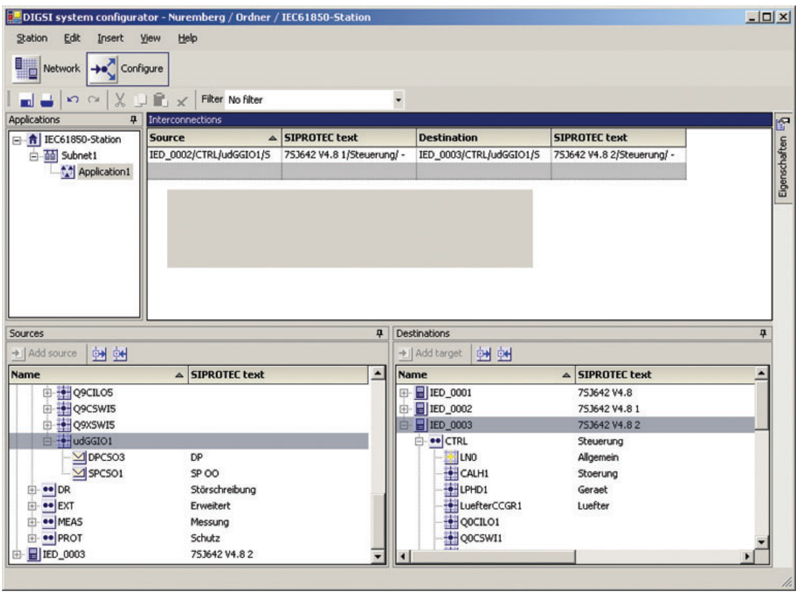
LSP2323-afpen.tif

Fig. 3/6
Quick and easy change of device displays like with a conventional image editor



LSP2485.tif

Fig. 3/7 All IEC 61850 information at a glance: Subnets, communicators, IP addresses...



LSP2484.tif

Fig. 3/8 Convenient connection of information between the IEC 61850 communicators

Selection and ordering data

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units Running under MS Windows 2000 / XP Professional Edition Includes: Device templates Comtrade Viewer “Getting started” manual (paper) Serial DIGSI connecting cables (for all devices) Incl. service (upgrade, update, Hotline, newsletter) Operating languages: English, Germen, French, Spanish, Italian, Chinese and Russian (selectable)	
Basis	
License for 10 computers, on CD-ROM (authorization by serial number)	7XS5400 - 0AA00
Scope of delivery includes: Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector)	7XV5100-4
Adaptor 9-/25-pin for 7XV5100-4 cable for protection unit with 25-pin connector	7XV5100-8H
Demo Multimedia presentation with operation videos (tutorial part) On CD-ROM	E50001-U321-A170-V1-7600
Professional DIGSI 4 Basis – without IEC 61850 System Configurator + SIGRA (fault record analysis) + CFC Editor (logic editor) + Display Editor + DIGSI 4 Remote	
License for 10 computers, on CD-ROM	7XS5402 - 0AA00
Scope of delivery includes: Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector)	7XV5100-4
Adaptor 9-/25-pin for 7XV5100-4 cable for protection unit with 25-pin connector	7XV5100-8H
DIGSI 4 Professional + IEC 61850 Professional and additional IEC 61850 System Configurator License for 10 computers, but only for licenses of DIGSI 4 Basis on CD-ROM	7XS5403-0AA00
Upgrade Basis → Professional Like “DIGSI 4 Professional”, but only for DIGSI 4 licencees	7XS5407 - 0AA00
Upgrade Basis → Professional + IEC 61850 License for 10 computers, but only for licensees of DIGSI 4 Basis, on CD-ROM	7XS5408-0AA00
DIGSI 4 Scientific Like “DIGSI 4 Professional”, but only for universities and research institutes, on CD-ROM	7XS5402-2AA00
DIGSI 4 you – Partner for Life Multimedia presentation of all features, on CD-ROM	E50417-A1174-C328
DIGSI 4 you – Start up Tutorial step-by-step introduction, on CD-ROM	E50417-A1174-C329
DIGSI 4 Copy Duplicate for 10 x licenses up to 9 copies per license may be ordered	7XS5490 - 0AA00

3

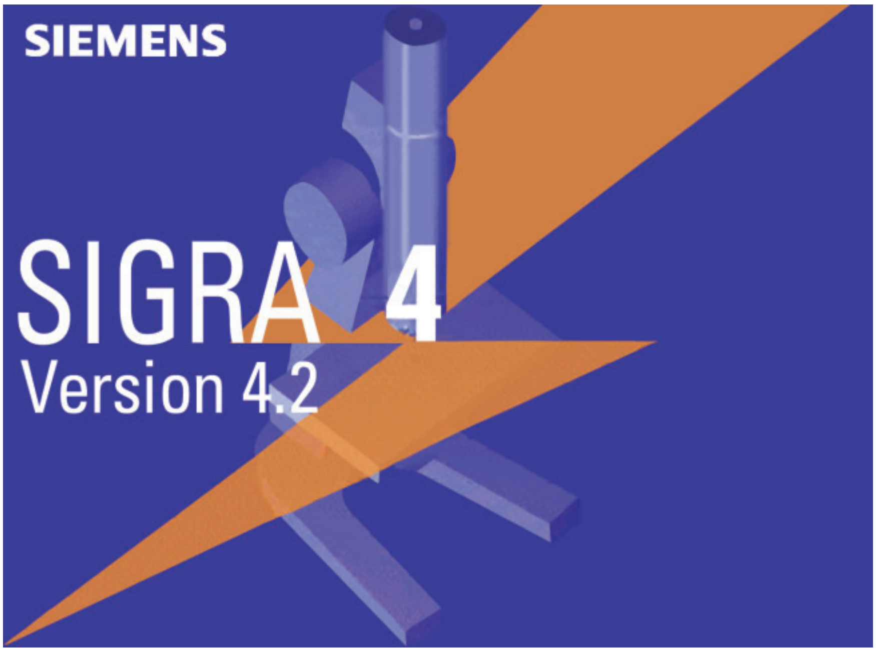
Selection and ordering data

Description	Order No.
SIGRA 4	
Software for graphical visualization, analysis and evaluation of fault records Running under MS Windows 2000 / XP Professional Edition Includes: Fault record templates Electronic manual (PDF) Detailed and step-by-step introduction, on separate CD-ROM	
SIGRA 4 applicable with or without DIGSI for Comtrade records; also applicable for devices of other manufacturers License for 10 computers, on CD-ROM (authorization by serial number)	7XS5410 - 0AA00
Trial Trial version (for test purposes; limited to 30 days) On CD-ROM	7XS5411 - 1AA00
DIGSI 4 Remote	
Software for remote control of Siemens protection units via modem (and star coupler, if necessary) Running under MS Windows 2000 / XP Professional Edition Includes: Electronic manual (PDF)	
Optional package for DIGSI 4 Basis License for 10 computers, on CD-ROM (authorization by serial number)	7XS5440 - 0AA00
IEC 61850 System Configurator	
Software for configuration of stations with IEC 61850 communication protocol. Running under MS Windows 2000 / XP Professional Edition. Optional package for DIGSI 4 Basis or DIGSI 4 Professional. License for 10 computers, on CD-ROM (authorization by serial number)	7XS5460-0AA00

Additional service free of charge

- All updates of DIGSI 4
- Customer Care Center
- DIGSI 4 Notes (quarterly newsletter)
- Access to the download area on the Internet at www.siprotec.com

SIGRA 4
Powerful Analysis of all Protection Fault Records



LSP2338-afp.tif

Description

It is of crucial importance after a line fault that the fault be quickly and fully analyzed so that the proper measures can be immediately derived from the evaluation of the cause. As a result, the original line condition can be quickly restored and the downtime reduced to an absolute minimum. It is possible with SIGRA 4 to display records from digital protection units and fault recorders in various views and measure them, as required, depending an the relevant task.

The product was designed by practical persons who have experience in the evaluation of faults. Accordingly, in addition to the usual time-signal display of the measured variables recorded, it is also designed to display vector diagrams, circle diagrams, bar charts for indicating the harmonics and data tables. From the measured values which have been recorded in the fault records, SIGRA 4 calculates further values, such as: absent quantities in the three-wire system, impedances, outputs, symmetrical components, etc. By means of two measuring cursors, it is possible to evaluate the fault trace simply and conveniently. Standard tools allow to evaluate just one fault record. With SIGRA, however, you can add additional fault records. This does not mean that you open a second fault record in a new window, but you add the signals of another fault record (e.g. from the opposite end of the line) to the current signal pattern by means of Drag & Drop. SIGRA 4 offers the unique possibility to display signals from various fault records in one diagram and fully automatically synchronize these signals to a common time base. In addition to finding out the details of the line fault, the localization of the fault is of special interest. A precise determination of the fault location will save time that can be used for the on-site inspection of the fault. This aspect is also supported by SIGRA 4 – with its "offline fault localization" feature.

SIGRA 4 can be used for all fault records which are available in the COMTRADE file format. The software product is easily and conveniently installed from a CD-ROM, it offers a comprehensive guiding system with demonstration, and an easily readable, practice-oriented manual describes the typical steps involved when using SIGRA.

The functional features and advantages of SIGRA 4 can, however, only be optimally shown on the product itself. For this reason, it is possible to test SIGRA 4 for 30 days with the trial version.

Function overview

- 6 types of diagrams: time signal representation (usual), circle diagram (e.g. for R/X), vector diagram (reading of angles), bar charts (e.g. for visualization of harmonics), table (lists values of several signals at the same instant) and fault locator (shows the location of a fault)
- Calculate additional values such as positive impedances, r.m.s. values, symmetric components, vectors, etc.
- Two measurement cursors, synchronized in each view
- Powerful zoom function
- User-friendly configuration via drag & drop
- Innovative signal configuration in a clearly-structured matrix
- Time-saving user profiles, which can be assigned to individual relay types or series
- Addition of other fault records to the existing fault record
- Synchronization of several fault records to a common time basis
- Easy documentation by copying diagrams to documents of other MS Windows programs
- Offline fault localization

Hardware requirements

- Pentium with 233 MHz processor
- 50 Mbyte of free hard disk space
- CD-ROM Drive
- Pointer device (i.e. mouse)

Software requirements

- MS Windows 2000/XP Professional Edition

Functions

When faults occur in electric power plants, fault recorders, now an integral component of modern numerical protection relays, record analog process variables (usually currents and voltages of the network nodes) and binary information (e.g. protection relay reactions) as a function of time. Those seeking a convenient tool for visualization and analysis of such fault records need look no further than the SIGRA 4 PC program from Siemens.

Different views of a fault record

In addition to the standard time signal representation, SIGRA 4 also supports the display of circle diagrams (e.g. R/X diagrams), vectors, which enable reading of angles, and bar charts (e.g. for visualization of harmonics). To do this, SIGRA uses the values recorded in the fault record to calculate additional values such as positive impedances, r.m.s. values, symmetric components, vectors, etc.

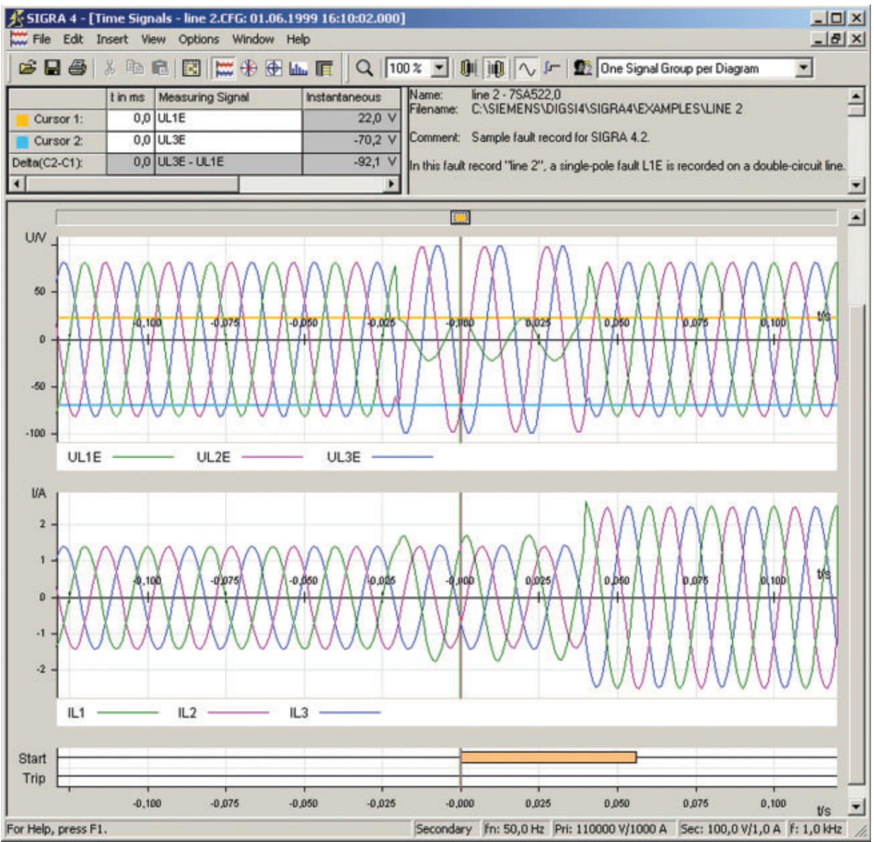
Measurement of a fault record

Two measurement cursors enable fast and convenient measurement of the fault record. The measured values of the cursor positions and their differences are presented in tables. The cursors operate interactively and across all views, whereby all cursor movement is synchronized in each view: In this manner, the cursor line enables simultaneous “intersection” of a fault occurrence in both a time signal characteristic and circle diagram characteristic. And of course a powerful zoom function ensures that you do not lose track of even the tiniest detail. The views of SIGRA 4 can accommodate any number of diagrams and each diagram any number of signals.

Operational features

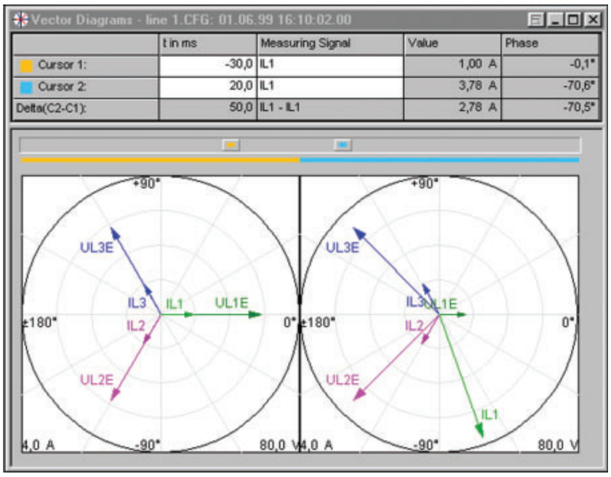
The main aim of the developers of SIGRA 4, who were assisted by ergonomic and design experts, was to produce a system that was simple, intuitive and user-friendly:

- The colours of all the lines have been defined so that they are clear and easily distinguishable. However, the colour, as well as the line style, the scale and other surface features, can be adjusted to suit individual requirements.
- Pop-up menus for each situation offer customized functionality – thus eliminating the need to browse through numerous menu levels (total operational efficiency).



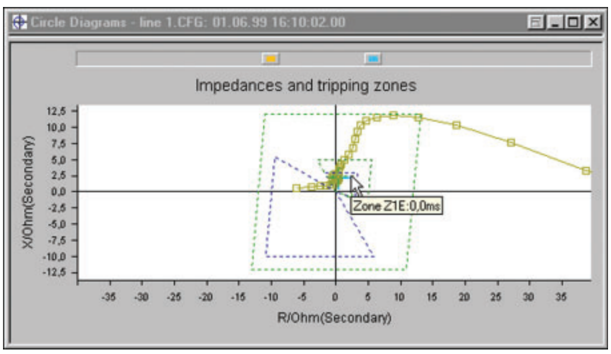
LSP2330-afpen.tif

Fig. 3/9 Typical time signal representation



LSP2331-afpen.tif

Fig. 3/10
Vector diagrams



LSP2332-afpen.tif

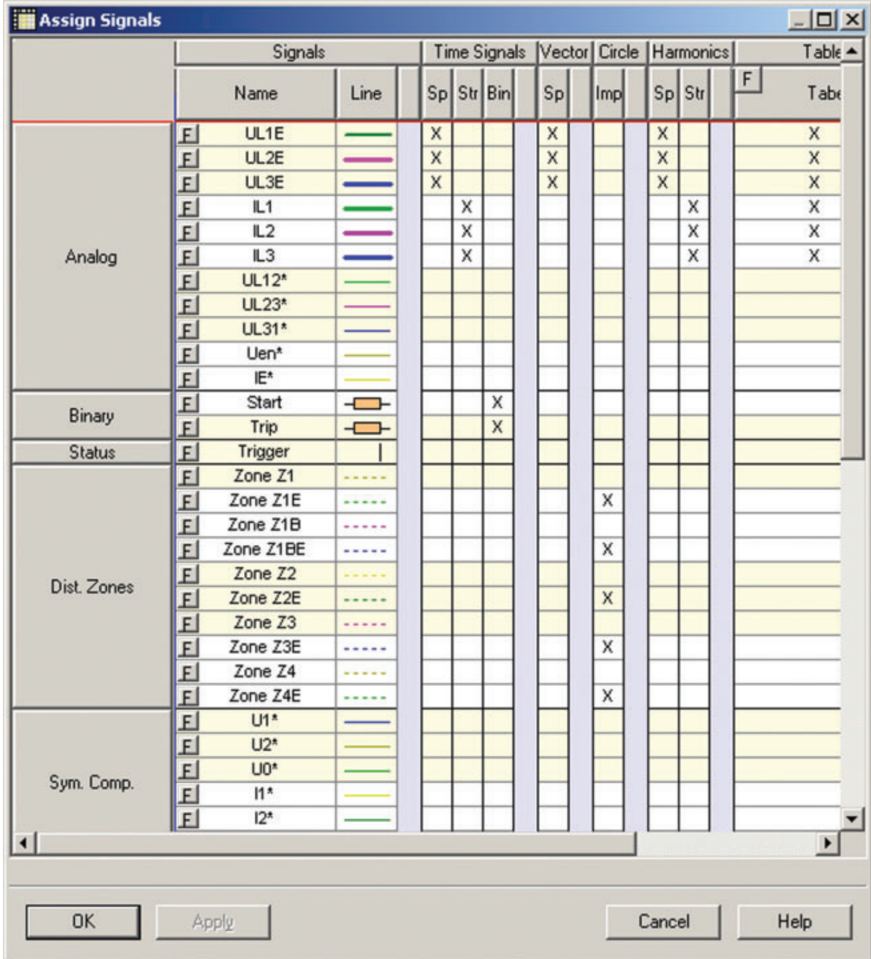
Fig. 3/11
Circle diagram

Functions

- Configuration of the individual diagrams is simple and intuitive: object-oriented, measured variables can be simply dragged and dropped from one diagram to another (also diagrams of different types).
- “Snap-to-grid” and “snap-to-object” movement of the cursor lines for easy and accurate placement.
- Redundancy: Most user tasks can be achieved via up to five different operational methods, thus ensuring quick and easy familiarization with the analysis software.
- Utilization of the available screen space is automatically optimized by an intelligent function that, like the “synchronous mouse cursors”, has since been patented.

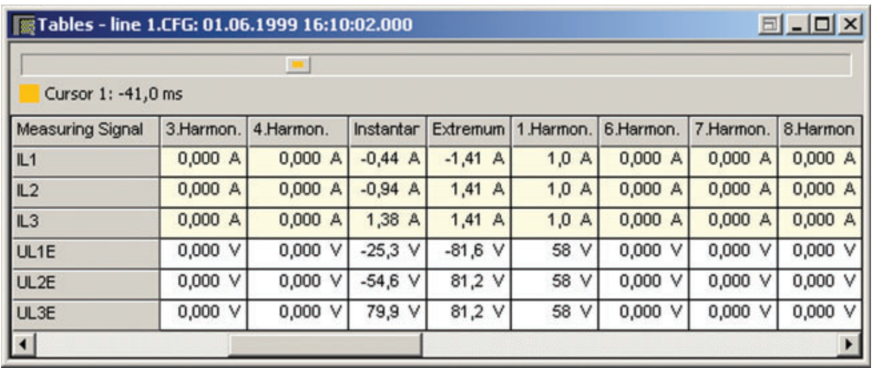
But even experts are impressed when it comes to speed and the repetition of frequent operational steps:

- For example, it is possible to store whole views, complete with settings (zoom, size), in so-called user profiles and to assign them to individual relay types or series. Then simply select from the toolbar and you can display each fault record quickly and easily as required. No need to waste time scrolling, zooming or resizing and moving windows.
- Additional fault records, e.g. from the other end of a line, can be added to existing records.
- A special function allows several fault records to be synchronized on a mutual time basis, thus considerably improving the quality of fault analysis.
- Fault localization with data from one line end the fault record data (current and voltage measurement) values are imported from the numerical protection unit into SIGRA 4. The fault localisator in SIGRA 4 is then started by the user and the result represented in % or in km of the line length, depending on the parameters assigned.
- Fault localization with data from both line ends. The algorithm of the implemented fault location does not need a zero-phase sequence system. Thus, measuring errors due to earth impedance or interference with the zero current of the parallel line are ruled out. Errors with contact resistance on lines with infeed from both ends are also correctly recorded.
  The above influences are eliminated due to the import of fault record data from both line ends into SIGRA. For this purpose, the imported data are synchronized in SIGRA and the calculation of the fault location is then started. Consequently, fault localization is independent from the zero-phase sequence system and the line infeed conditions and produces precise results to allow as fast an inspection of the fault location as possible.
- So-called marks, which users can insert at various instants as required, enable suitable commentary of the fault record. Each individual diagram can be copied to a document of another MS Windows program via the “clipboard”: documenting fault records really could not be easier.



LSP2333-afpen.tif

Fig. 3/12 Concise matrix for assigning signals to diagrams


Tables - line 1.CFG: 01.06.1999 16:10:02.000

Cursor 1: -41,0 ms

Measuring Signal	3.Harmon.	4.Harmon.	Instantar	Extremum	1.Harmon.	6.Harmon.	7.Harmon.	8.Harmon
IL1	0,000 A	0,000 A	-0,44 A	-1,41 A	1,0 A	0,000 A	0,000 A	0,000 A
IL2	0,000 A	0,000 A	-0,94 A	1,41 A	1,0 A	0,000 A	0,000 A	0,000 A
IL3	0,000 A	0,000 A	1,38 A	1,41 A	1,0 A	0,000 A	0,000 A	0,000 A
UL1E	0,000 V	0,000 V	-25,3 V	-81,6 V	58 V	0,000 V	0,000 V	0,000 V
UL2E	0,000 V	0,000 V	-54,6 V	81,2 V	58 V	0,000 V	0,000 V	0,000 V
UL3E	0,000 V	0,000 V	79,9 V	81,2 V	58 V	0,000 V	0,000 V	0,000 V

LSP2334-afpen.tif

Fig. 3/13 Table with values at a definite time

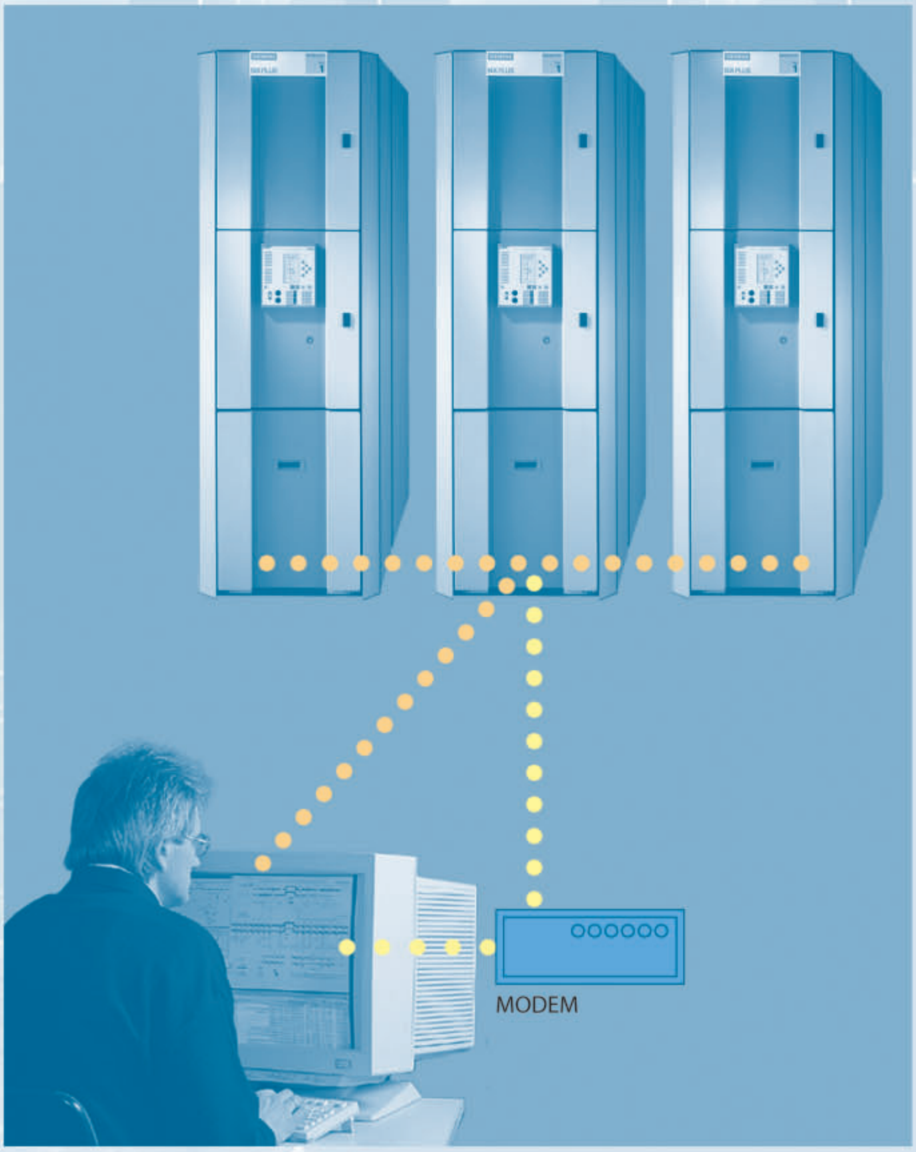
Scope of delivery

The software product is quick and easy to install from a CD-ROM. It has a comprehensive “help” system. An user-friendly and practical manual offers easy step-by-step instructions on how to use SIGRA.

Selection and ordering data

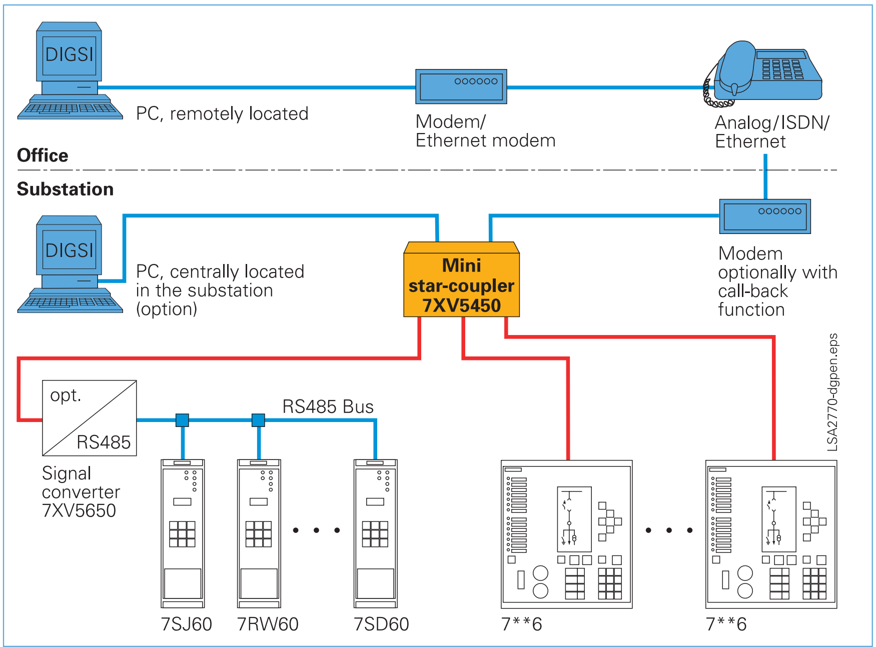
Description	Order No.
SIGRA 4	
Software for graphical visualization, analysis and evaluation of fault records Running under MS Windows 2000 / XP Professional Edition Includes: Fault record templates Electronic manual (PDF) Detailed and step-by-step introduction, on separate CD-ROM Incl. sevice (upgrade, update, Hotline, newsletter) Operating languages: English, German, French, Spanish, Italian Chinese and Russian (selectable)	
SIGRA 4 applicable with or without DIGSI for Comtrade records; also applicable for devices of other manufacturers License for 10 computers, on CD-ROM (authorization by serial number)	
SIGRA 4 for DIGSI Optional package for DIGSI 4 Basis	7XS5410-0AA00
SIGRA 4 Stand Alone Applicable without DIGSI	7XS5416-0AA00
SIGRA 4 Scientific Like "SIGRA 4 Stand Alone", but only for universities and research institutes	7XS5416-1AA00
SIGRA 4 you – Start up Multimedial presentation of all product features with operational video clips Release scheduled for Jan. 2006	E50417-A1176-C341-A1
Trial Trial version (for test purposes; limited to 30 days) On CD-ROM	7XS5411-1AA00
Upgrade SIGRA 4 Trial → Stand Alone Authorization by serial number for upgrade to unlimited functionality	7XS5416-2AA00

Communication



4

Communication



Description

Communication interfaces on protection relays are becoming increasingly important for the efficient and economical operation of substations and networks. The interfaces can be used for:

- Accessing the protection relays from a PC using the DIGSI operating program. Remote access via modem, Ethernet modem is possible with a serial service port at the relay. This allows remote access to all data of the protection relay.
- Integrating the relays into control systems with IEC 60870-5-103 protocol, PROFIBUS-FMS protocol, PROFIBUS-DP protocol, DNP 3.0 protocol and MODBUS protocol.
  The new standardized IEC 61850 protocol is available since Oct. 2004 and with its SIPROTEC units Siemens has provided this standard as the first manufacturer worldwide.
- Peer-to-peer communication of differential relays and distance relays to exchange real-time protection data via fiber-optic cables, communication network, telephone networks or analog pilot wires.

Function overview

Description

- Remote communication with DIGSI
- Remote communication with SIPROTEC 4 units
- Remote communication with SIPROTEC 3 units and SIPROTEC ‘600 units

Typical applications

- SIPROTEC 4 units on an RS485 bus
- SIPROTEC 4 units with FO/RS485
- Mixed system SIPROTEC 4, SIPROTEC 3 units, SIPROTEC ‘600 units
- Configuration with active star-coupler

Integration into substation control systems

Integration into the SICAM power automation system

Integration into other systems

Description

Remote communication with DIGSI

By using the remote communication functions of DIGSI it is possible to access relays from your office via the telephone network. So you do not have to drive to the substation at all and, if you need to carry out a quick fault analysis, for example, you can transfer the fault data into your office in just a few minutes so that you can use DIGSI to evaluate it.

Another alternative is the ability to access all the units of a substation from a central point within that station. This saves you having to connect your PC individually to all the relays in the station.

In both cases you need a few simple communication units and a PC with DIGSI and a remote communication component installed. The data traffic with DIGSI uses a secure protocol based on the IEC standard similar to IEC 60870-5-103 so that, amongst other things, the relays have unique addresses for accessing purposes. A high level of data integrity is achieved through the check sum incorporated in the telegram. Any telegrams that might become distorted during transmission are repeated. A comparison of parameters between relay and PC to ensure that they match also improves the integrity. There are other security functions too such as passwords and a substation modem call-back function which can also be triggered from events.

Remote communication with SIPROTEC 4 units

SIPROTEC 4 units are well equipped for remote communication. A separate serial service interface for the protection engineer, independent of the system interface, allows the units to be easily integrated into any communication configuration. The front interface then remains free for local operation. Together with a flexibility in the choice of interface, i.e. optical with an ST connector for multi-mode FO cables or electrical for RS232 or RS485 hard-wired connections, it is easy to create the optimum solution for any particular application.

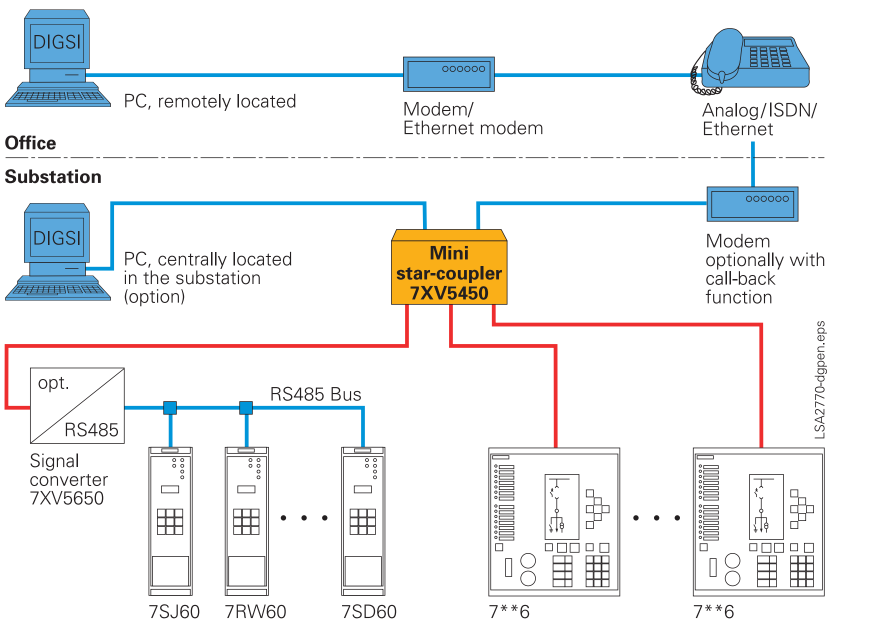


Fig. 4/1 Remote relay communication

With SIPROTEC 4 units you can also use PROFIBUS-FMS to provide a central link with DIGSI via the control system interface. For this you will need a PC with a special PROFIBUS card that must be connected to the PROFIBUS system. This solution is intended exclusively for SIPROTEC 4 units with PROFIBUS-FMS.

Since Oct. 2004, a relay can be accessed remotely with DIGSI via an Ethernet interface in the relay and with the IEC 61850 protocol. This allows access to the relays via an Ethernet network. Some relays include a Web server, so an Internet browser can also be used for remote access via Ethernet.

Remote communication with SIPROTEC 3 and series '600 relays

These relays are ideal for applications involving remote communication. When configuring the actual communication system, however, it is important to take into account the smaller number of relay interfaces compared with SIPROTEC 4 units.

In the case of SIPROTEC 3 units, communication is normally effected via the system interface at the back of the unit. If this interface is already being used for communication with the substation control system, the front interface can be used for the DIGSI communication instead. A suitable connector module is available to convert from electrical to optical interface.

Series '600 relays normally have one RS485 interface which can be used for communication either with the substation control system or with DIGSI.

Note:
Relays series V2 are available with a system interface, communication with DIGSI is effected with ASCII routines which cannot be addressed. We, however, offer the opportunity for central operation for this purpose using active mini star-coupler 7XV5550.

Typical applications

An extensive range of communication components, such as modems, star couplers, optoelectric converters, prefabricated FO connection cables and electric connection cables (see part 14 of this catalog) allows you to create a variety of different solutions: FO connections immune to interference or cost-effective solutions using the two-wire RS485 electric bus.

The following examples give some indication of what configurations are possible, which items are needed for the purpose and what baud rates are possible.

Example 1: SIPROTEC 4 units on an RS485 bus

Remote communication is effected via a private or public telephone network with both analog or digital telephone lines being possible. An Ethernet network can also be used together with Ethernet modems. The 8N1 data format and an analog baud rate of 57.6/64 kbit/s have become established as the standard for serial modem links. The connection between modem and units is initially optical. An FO/RS485 converter 7XV5650 that can be installed close to the units then converts the signals for the RS485 bus. Up to 31 relays can be connected to the RS485 bus. Particularly in the case of modems, we recommend the use of the types of units listed in part 14. Other accessories can be found in the same part (see Fig. 4/2).

Example 2: SIPROTEC 4 units with FO/RS485

In the case of larger substations with longer distances we recommend the use of FO connection cables. The following example shows a mixed system of optical and electrical connections. Typically, all relays in a cubicle can be linked together via RS485 and the cubicles themselves can be connected to the star coupler via FO cables (see Fig. 4/3).

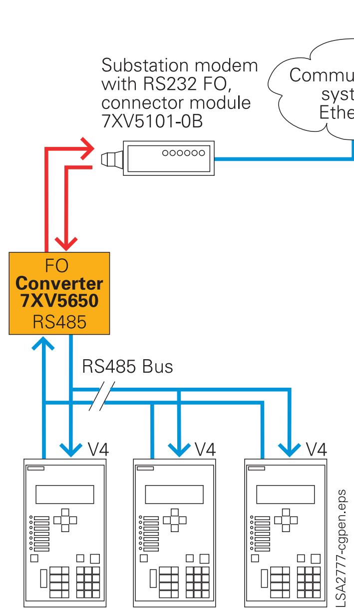


Fig. 4/2 SIPROTEC 4 units on an RS485 bus (Example 1)

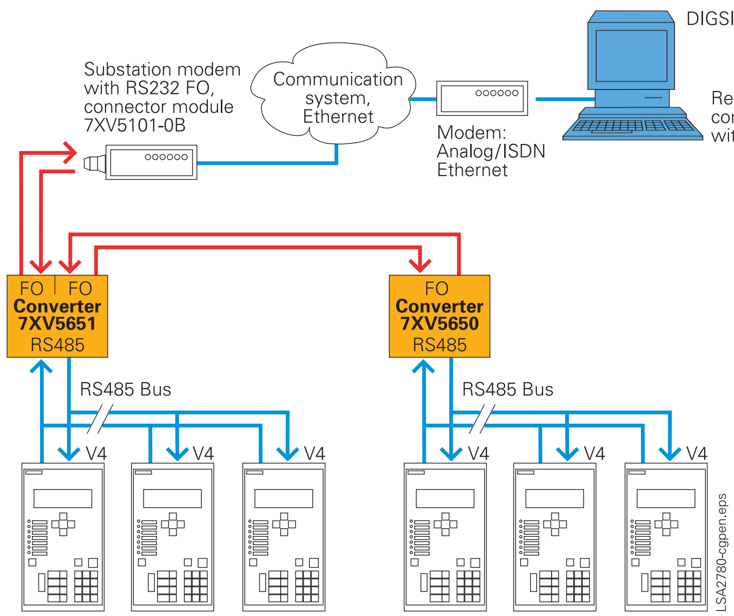


Fig. 4/3 Two groups of SIPROTEC 4 units on an RS485 bus (Example 2)

Typical applications

Example 3: Mixed system – SIPROTEC 4, SIPROTEC 3, series ‘600

Relays from different families can be integrated into a remote communication system, as illustrated in Example 3 (see Fig. 4/4). This example also shows how relays can be integrated by means of FO links and star couplers. With this kind of arrangement the baud rate for all links must be set at 19.2 kbaud because the SIPROTEC 3 units and the series ‘600 relays cannot support a higher baud rate. In this case we recommend to use the 7XV5550 active mini star-coupler (see Fig. 4/5).
Communication will then generally be at 57.6/64 kbit/s on the modem link. For any units that cannot operate at this baud rate the active star-coupler will convert the rate accordingly.

Example 4: Configuration with active star-coupler

With this configuration it is also possible to integrate relays that can only be connected via the front interface and whose maximum baud rates are less than 19.2 kbaud (see Fig. 4/5).

The following points must be noted with this type of configuration:

- One output of the active mini star-coupler is used to service several SIPROTEC 4 units through further star couplers or RS485 converters. On that output, a mixed system containing SIPROTEC 3 and series ‘600 relays should be avoided so that 57600 baud operation is possible for SIPROTEC 4 relays.
- Several SIPROTEC 3 units and series ‘600 relays can also be connected to another output of the active mini star-coupler (via mini star-couplers or RS485 converters). The baud rate for this output must be set less or equal to 19200 baud.
- Relays that are not available with communication functions according to IEC 60870-5-103 protocol (e.g. 7VE51, 7VK51, 7SV51 and older firmware versions of some relays) can also be connected via the active star-coupler as illustrated in Fig. 4/5. In this case one output must be assigned to each relay. The baud rate must be set according to the unit.

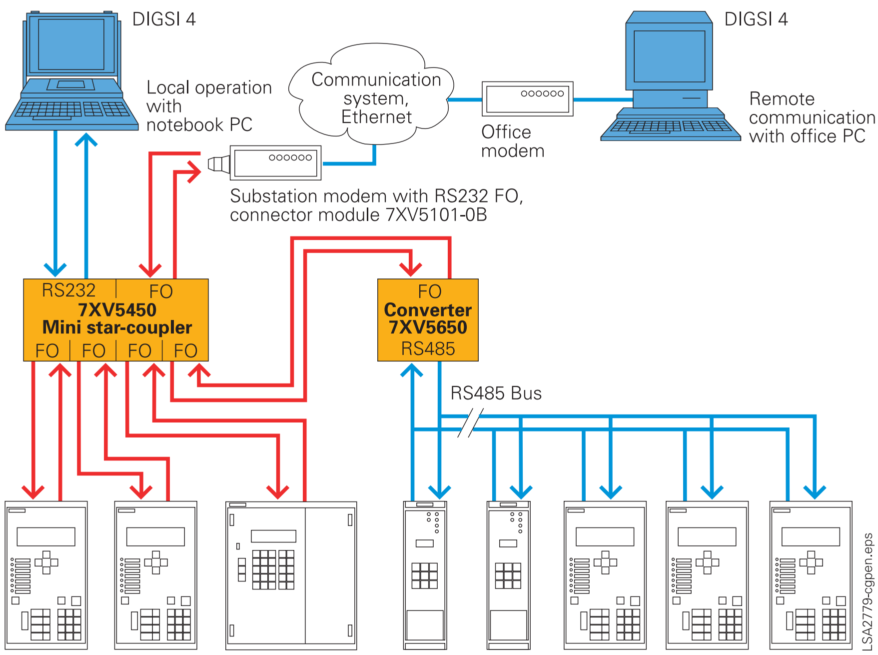


Fig. 4/4 Mixed system, FO/RS485 with units from different families (Example 3)

The solutions for central and/or remote communication with SIPROTEC units have easy upgrade compatibility. Different versions of relays can be integrated into a remote communication concept. This is supported by the substation and device management in the DIGSI software. A substation can be retrofitted with add-on remote communication components provided it has the communication connection available. And changing of the telephone line from, say, analog to digital does not necessitate the replacement of all components. Also, Ethernet networks can be used. The telephone modem is then replaced by an Ethernet modem. The infrastructure in the substation remains unchanged.

Typical applications

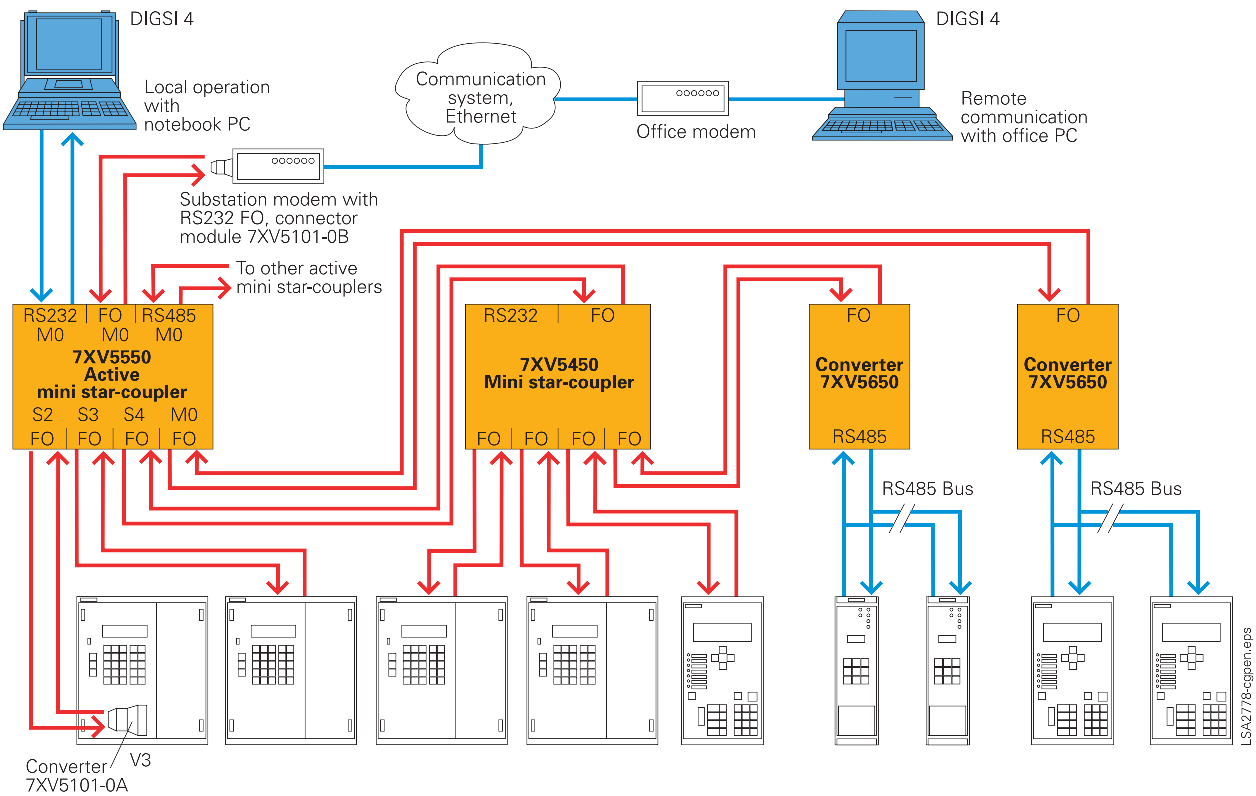


Fig. 4/5 Mixed system with relays from different families, with active star-coupler (Example 4)

Integration into substation control systems

Almost all SIPROTEC units can be integrated into substation control systems via serial communication interfaces.

The relays can be supplied as part of an integrated Siemens system offering all substation control and protection. In addition, the relays can also be integrated into other control systems via standard protocols. An integrated system offers type-tested functions, consistent configuration and optimally coordinated communication protocols. SICAM and SINAUT LSA are two of the proven systems available from Siemens. SICAM PAS is a system, which also offers Ethernet communication with IEC 61850.

For situations where you would like to integrate SIPROTEC units into other control systems we can offer open communication interfaces. In addition to the IEC 60870-5-103 protocol that is available in almost all relays we can also offer other communication protocols for SIPROTEC 4 units like PROFIBUS-DP, MODBUS or DNP 3.0. IEC 61850 is be available since Oct. 2004.

Relay type	*Substation control telegram*					
	IEC 61850	*IEC 60870-5-103*	*PROFIBUS-FMS*	*PROFIBUS-DP*	*MODBUS*	*DNP 3.0*
6MD63	V4.6	V4.0	V4.0	V4.2	V4.2	V4.2
6MD663/4	V4.6	V4.2	V4.0	V4.2		
7SA51.		V3.0				
7SA522	V4.6	V4.0	V4.2	V4.2		V4.2
7SA6..	V4.6	V4.0	V4.0	V4.2		V4.2
7SD50.		V3.0				
7SD51.		V3.0				
7SD52.		V4.0	V4.3	V4.21		V4.21
7SD61		V4.0		V4.2		V4.2
7SJ51./53.		V3.0				
7SJ600		V1.0				
7SJ602		V1.0 / V3.5		V3.5	V3.5	
7SJ61/62/63	V4.6	V4.0	V4.0	V4.2	V4.2	V4.2
7SJ64	V4.6	V4.0	V4.0	V4.4	V4.4	V4.4
7UM5.		V3.0				
7UM61		V4.0		V4.0	V4.1	V4.1
7UM62	V4.6	V4.0		V4.0	V4.0	V4.1
7UT5.		V3.0				
7UT6.	V4.6[1)]	V4.0	V4.0	V4.0	V4.0	V4.0
7VE6		V4.0		V4.0	V4.0	V4.0
7VK61		V4.0	V4.0	V4.0		V4.0

1) 7UT613, 7UT63 available as of 01/2006.

4

Integration into substation control systems

The table on page 4/7 shows which communication protocols are available in the various SIPROTEC relays starting with the firmware version. The latest version can be found on the Internet at www. siprotec.com.

IEC 61850 protocol

Since Oct. 2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations, Siemens is the first manufacturer supporting the protocol in its devices. By means of this protocol, information can also be exchanged directly between bay units so as to enable the creation of simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

It will also be possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor will also provide a few items of unit specific information in browser windows.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit (and also control commands) can be transferred via published, Siemens-specific extensions.

PROFIBUS -FMS

PROFIBUS-FMS is an internationally standardized communication system (EN 50170) for efficient performance of communication tasks in the bay area. SIPROTEC 4 units use a profile specially optimized for protection and control requirements. The data can be flexibly assigned to the system interface with DIGSI. DIGSI can also work on the basis of PROFIBUS-FMS. The units are linked to a SICAM automation system.

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred. The information is assignable to a mapping file with DIGSI.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit vendors. SIPROTEC units behave as MODBUS slaves, making their information available to a master or receiving information from it. Information is assignable to a mapping file with DIGSI.

DNP 3.0 protocol

Power supply corporations overseas use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels, SIPROTEC units behave as DNP slaves, supplying their information to a master system or receiving information from it. Information is assignable to a mapping file with DIGSI.

	Substation control port B						Port C
	IEC 61850	IEC 60870-5-103	PROFIBUS-FMS	PROFIBUS-DP	MODBUS	DNP 3.0	DIGSI
Alarms (relay → central unit)	√ with time stamp	√ with time stamp	√ with time stamp	√ with time stamp	√ with time stamp	√ with time stamp	√ with time stamp
Commands (BC/central unit → relay)	√	√	√	√	√	√	√
Measured values	√	√	√	√	√	√	√
Time synchronization	√	√	√	√	√	√	1)
Fault records (sampled values)	√	√	√	Separate port (with DIGSI)[2)]	Separate port (with DIGSI)[2)]	Separate port (with DIGSI)[2)]	
Protection settings	√ (with DIGSI)	Separate port (with DIGSI)[3)]	√ (with DIGSI)	Separate port (with DIGSI)[3)]	Separate port (with DIGSI)[3)]	Separate port (with DIGSI)[3)]	√

1) There is no time synchronization via this protocol. For time synchronization purposes it is possible to use a separate time synchronization interface (Port A in SIPROTEC 4 relays).

2) The transmission of fault records is not part of the protocol. They can be read out with DIGSI via the service interface Port C or the front operating interface.

3) This protocol does not support the transmission of protection settings. Only setting groups can be changed. For this purpose you should use the service interface or the front operating interface together with DIGSI.

Integration into the SICAM power automation system

SIPROTEC 4 is tailor-made for use with the SIMATIC-based SICAM power automation system. The SICAM family comprises the following components:

- SICAM RTU, the modern telecontrol system with automation and programmable logic functions
- SICAM PAS, the PC-based automation and communication system

Data management and communication is one of the strong points of the SICAM / SIPROTEC 4 system. Powerful engineering tools (SICAM plus TOOLS based on STEP 7 and SICAM WinCC) make working with SICAM convenient and easy. SIPROTEC 4 units are optimally matched for use in SICAM PAS. With SICAM and SIPROTEC 4 continuity exists at three crucial points:

- Data management
- Software architecture
- Communication

All central system components (SICAM and SIPROTEC 4, CPUs, SICAM WinCC, SICAM plus TOOLS, bay controllers and protection relays), as well as the DIGSI 4 operating program, are established on the same basis. The ability to link SICAM/ SIPROTEC to other substation control, protection and automation components is assured, thanks to open interfaces such as IEC 60870-5-103 protocol and the Ethernet-based IEC 61850 protocol. Other protocols like PROFIBUS-DP, DNP 3.0 and MODBUS are also supported.

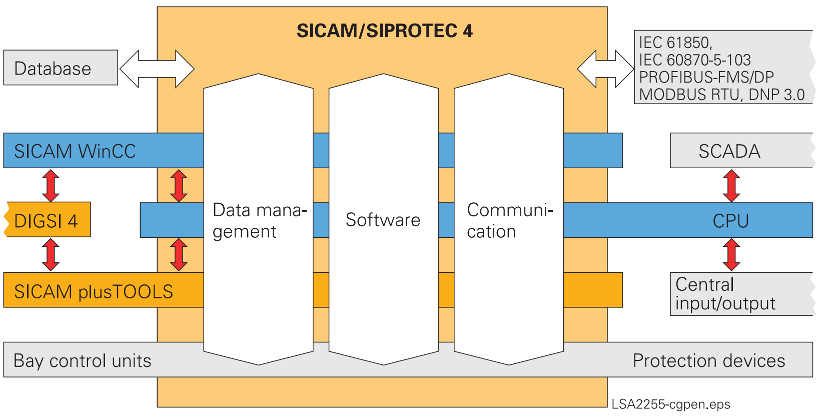


Fig. 4/6 SICAM/SIPROTEC 4 architecture

Integration into substation automation system

SIPROTEC 4 is tailor-made for use with the SICAM substation automation system. Over the low-cost electrical RS485 bus, or in an interference-free manner via the optical double ring, the units exchange information with the control system. Units featuring IEC 60870-5-103 interfaces can be connected to SICAM interference free and radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers.

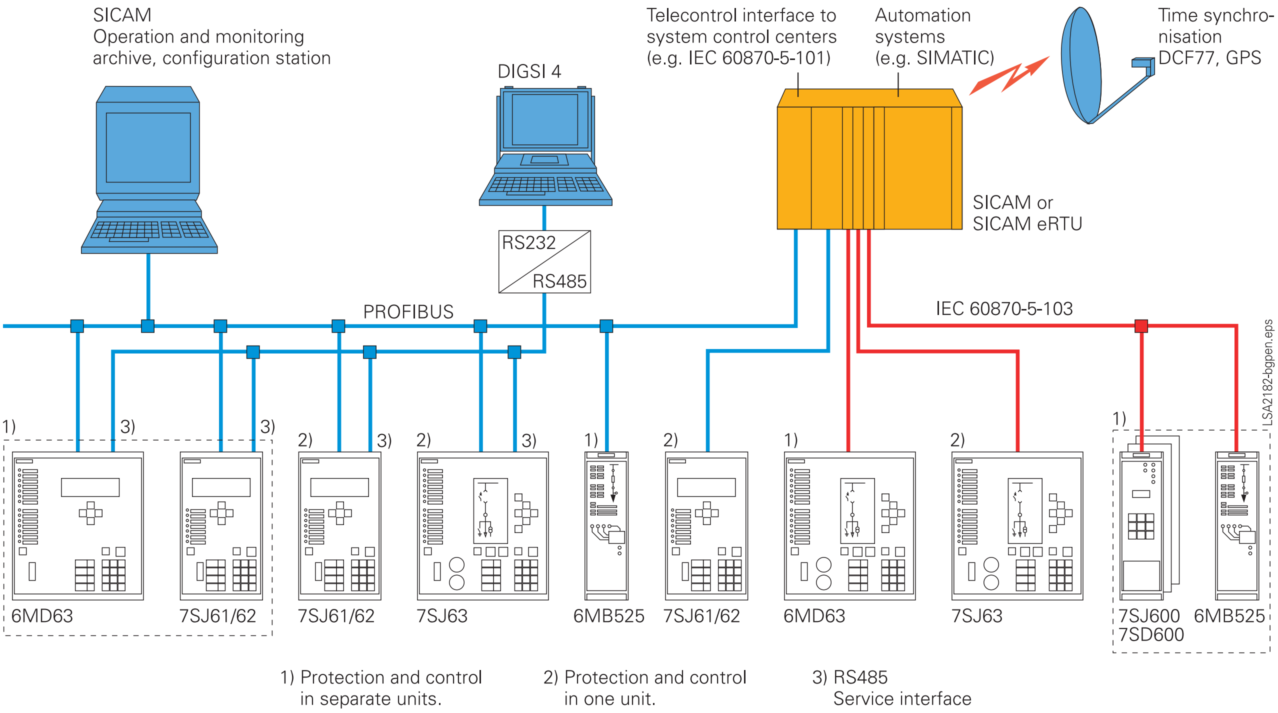


Fig. 4/7 Communication structure with substation automation system

Integration into the SICAM PAS power automation system

SIPROTEC 4 is tailor-made for use with the SICAM power automation system together with IEC 61850 protocol. Via the 100 Mbit/s Ethernet bus, the units are linked electrically or optically to the station PC with PAS. Connection may be simple or redundant. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. Units featuring an IEC 60870-5-103 interface or other serial protocols are connected via the Ethernet station bus to SICAM PAS by means of serial/Ethernet converters (see Fig. 4/8). DIGSI and the Web monitor can also be used over the same station bus.

Together with Ethernet/IEC 61850, an interference-free optical solution is also provided (see Fig. 4/9). The Ethernet interface in the relay includes an Ethernet switch. Thus, the installation of expensive external Ethernet switches can be avoided. The relays are linked in an optical ring structure.

Integrated SNMP (Simple Network Management Protocol) facility allows the supervision of the network from the station controller.

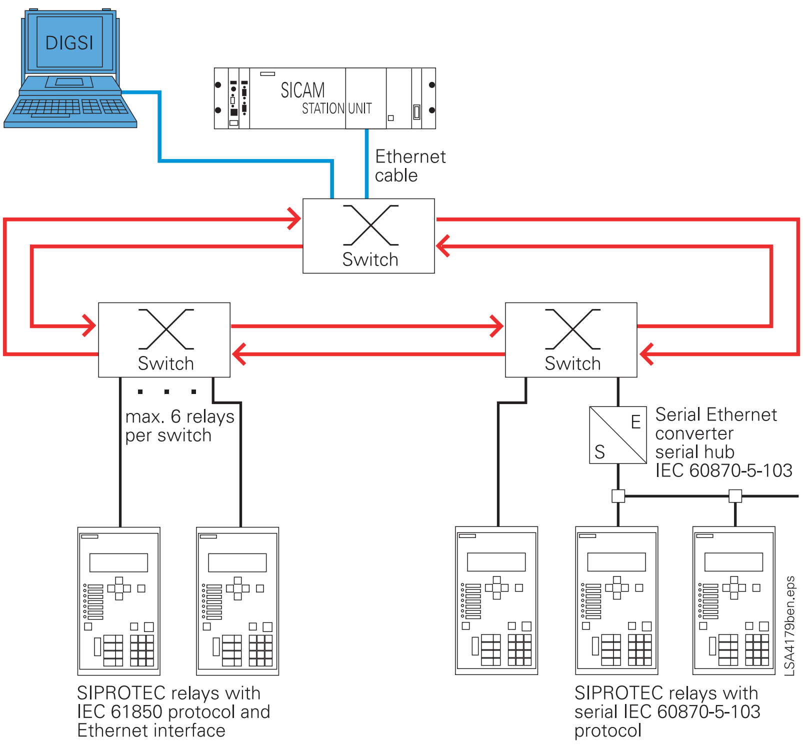


Fig. 4/8 Ethernet-based system with SICAM PAS with electrical Ethernet interface

Integration into a substation automation system of other makes

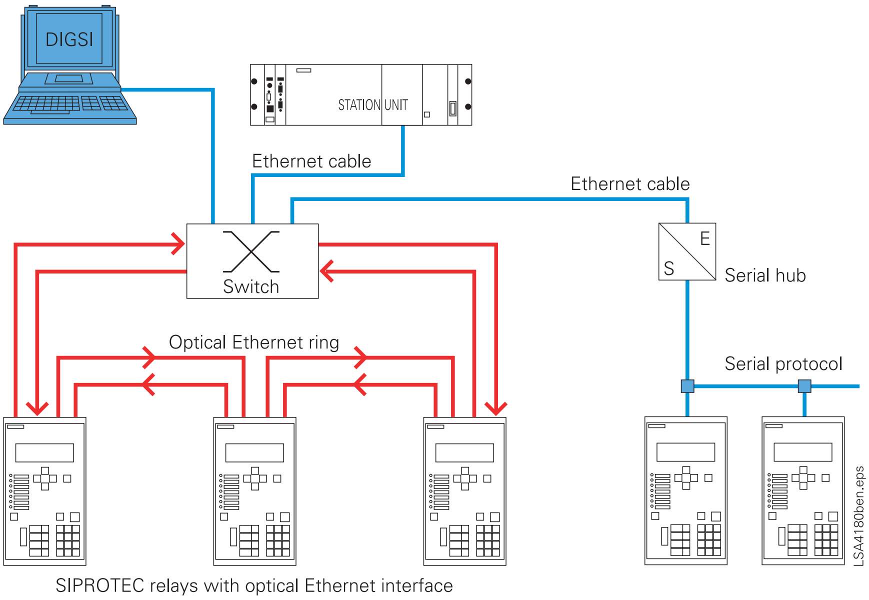


Fig. 4/9 Ethernet-based system with SICAM PAS with optical Ethernet interface

Thanks to the standardized interfaces, IEC 61850, IEC 60870-5-103, DNP3.0, MODBUS, PROFIBUS-DP, SIPROTEC units can also be integrated into non-Siemens systems or in SIMATIC S5/S7. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

Solution without substation control system

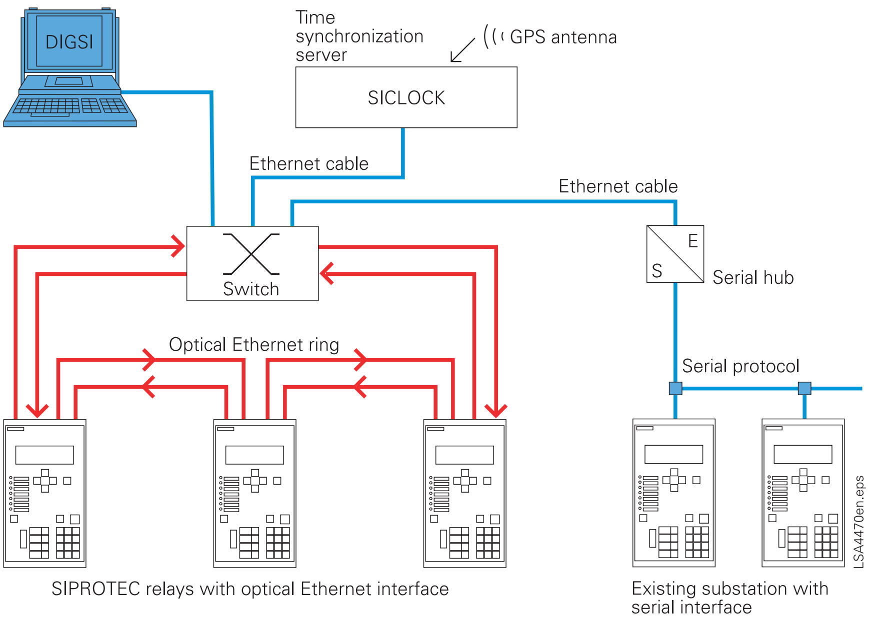


Fig. 4/10 Ethernet-based system with optical Ethernet interface and migration of relays with serial protocol

Ethernet-based communication with optical Ethernet interface between SIPROTEC protection relays without substation control offers many advantages:

- Fast remote access via DIGSI 4
- High-speed setting and parameterization with DIGSI 4
- Interlocking between different field devices and exchange of binary signals via GOOSE messages of IEC 61850
- Common time synchronization of all relays from central time synchronization server (eg. SICLOCK)

For automation of new substations (or plants) and modernization of existing substations you get future investment security, without additional investment.

Overcurrent Protection

Page

5

SIPROTEC easy 7SJ45
Numerical Overcurrent Protection Relay Powered by CTs

Fig. 5/1 SIPROTEC easy 7SJ45 numerical overcurrent protection relay powered by current transformers (CT)

Description

The SIPROTEC easy 7SJ45 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The 7SJ45 relay does not require auxiliary voltage supply. It imports its power supply from the current transformers.

Function overview

- Operation without auxiliary voltage via integrated CT power supply
- Standard current transformers (1 A/5 A)
- Low power consumption: 1.4 VA at I_N (of the relay)
- Easy mounting due to compact housing
- Easy connection via screw-type terminals

Protection functions

- 2-stage overcurrent protection
- Definite-time and inverse-time characteristics (IEC/ANSI)
- High-current stage I>> or calculated earth-current stage I_E> or I_{Ep}> selectable
- Trip with pulse output (24 V DC / 0.1 Ws) or relay output (changeover contact)
- Repetition of trip during circuit-breaker failure (relays with pulse output)
- Combination with electromechanical relays is possible due to the emulation algorithm

Monitoring functions

- Hardware and software are continuously monitored during operation

Front design

- Simple setting via DIP switches (self-explaining)
- Settings can be executed without auxiliary voltage – no PC
- Integrated mechanical trip indication optionally

Additional features

- Optional version available for most adverse environmental conditions (condensation permissible)
- Flush mounting or surface (rail) mounting

5

Application

The SIPROTEC easy 7SJ45 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The convenient setting with DIP switches is self-explanatory and simple.

The 7SJ45 relay does not require auxiliary voltage supply. It imports its power supply (1.4 VA at I_N, sum of all phases) from the current transformers.
Impulse output for low-energy trip release or contact output for additional auxiliary transformer are available. An optional integrated trip indication shows that a trip occurred.

ANSI	IEC	Protection functions
50	$I>>$	Instantaneous overcurrent protection
50, 51	$I>t$, I_p	Time-overcurrent protection (phase)
50N, 51N	$I_E>t$, I_{Ep}	Time-overcurrent protection (earth)

Construction

Within its compact housing the protection relay contains all required components for:

- Measuring and processing
- Alarm and command output
- Operation and indication (without a PC)
- Optional mechanical trip indication
- Auxiliary supply from current transformers
- Maintenance not necessary

The housing dimensions of the units are such that the 7SJ45 relays can in general be installed into the existing cutouts in cubicles. Alternative constructions are available (surface mounting and flush mounting). The compact housing permits easy mounting, and a version for the most adverse environmental conditions, even with extreme humidity, is also available.

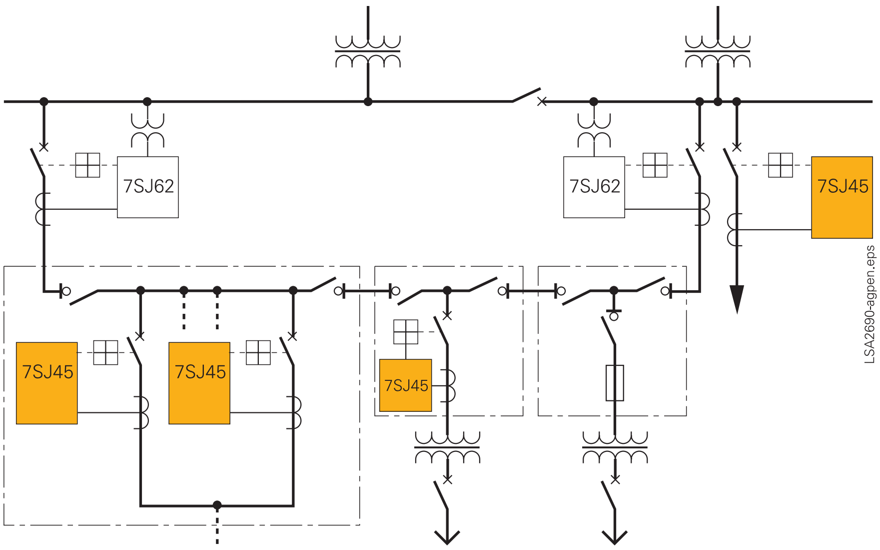


Fig. 5/2 Typical application

Fig. 5/3 Application in distribution switchgear

Fig. 5/4 Screw-type terminals

Protection functions

The overcurrent function is based on phase-selective measurement of the three phase currents.

The earth (ground) current I_E (Gnd) is calculated from the three line currents I_{L1} (A), I_{L2} (B), and I_{L3} (C).

The relay has always a normal stage for phase currents $I>$ (50/51). For the second stage, the user can choose between a high-current stage for phase currents $I>>$ (50) or a normal stage for calculated earth currents $I_E>$ (50N/51N).

The inverse-time overcurrent protection with integrating measurement method (disk emulation) emulates the behaviour of electromechanical relays.

The influence of high-frequency transients and transient DC components is largely suppressed by the implementation of numerical measured-value processing.

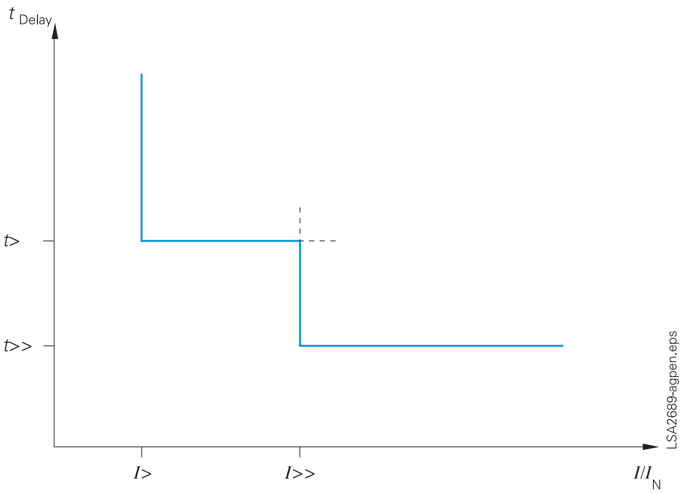


Fig. 5/5 Definite-time overcurrent characteristic

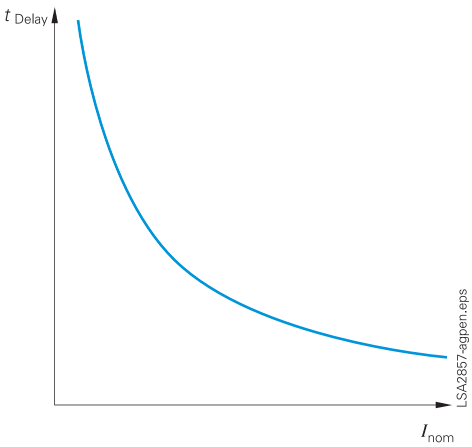


Fig. 5/6
Inverse-time overcurrent characteristic

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Moderately inverse/normal inverse	•	•
Very inverse	•	•
Extremely inverse	•	•

Connection diagrams

Pulse output or relay output are optionally available.

Pulse output

These relays require a low-energy trip release (24 V DC/0.1 Ws) in the circuit-breaker, and are intended for modern switchgear. In case of circuit-breaker failure, a repetition of the tripping signal is initiated.

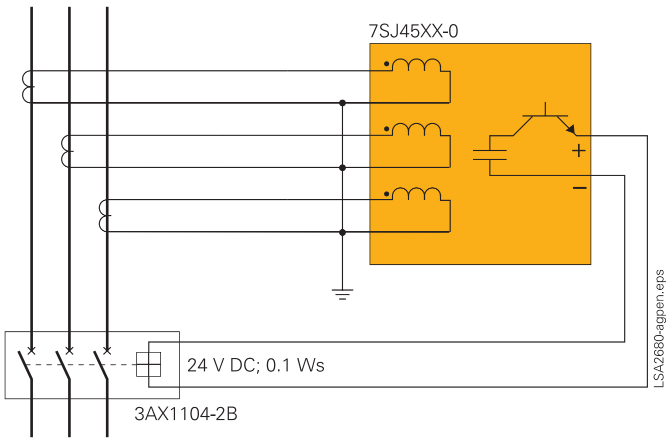


Fig. 5/7 Connection of 3 CTs with pulse output

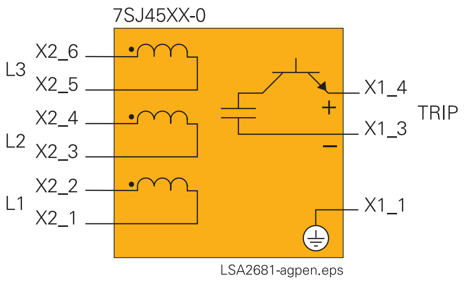


Fig. 5/8 Connection diagram 7SJ45 with impulse output

Relay output

These relays can be applied with all conventional switchgear. A transformer that provides the trip circuit energy, must be connected in the current transformer circuit.

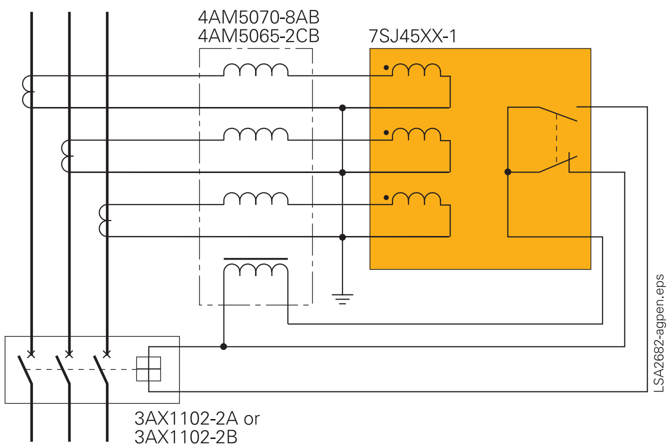


Fig. 5/9 Connection of 3 CTs with trigger transformer and relay output

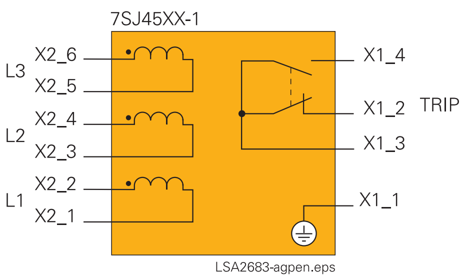


Fig. 5/10 Connection diagram 7SJ45 with relay output

Technical data

General unit data	
Analog input	
System frequency I_N	50 or 60 Hz (selectable)
Current transformer inputs	
Rated current, normal earth current I_N	1 or 5 A
Power consumption At I_N = 1 / 5 A	 Approx. 1.4 VA at I_N (relay)
Rating of current transformer circuit Thermal (r.m.s.)	 50 · I_N for 1 s 15 · I_N for 10 s 2 · I_N continuous
Dynamic (peak)	100 · I_N for half a cycle
Recommended primary current transformers	10 P 10, 2.5 VA or according to the requirements and required tripping power
Output relays	
Pulse output (7SJ45XX-0*)	
Number	1 pulse output 24 V DC / 0.1 Ws
Relay output (7SJ45XX-1*)	
Number	1 changeover contact
Contact rating	Make 1000 W/VA Break 30 VA 40 W resistive 25 VA at L/R ≤ 50 ms
Rated contact voltage	≤ 250 V DC or ≤ 240 V AC
Permissible current per contact	5 A continuous 30 A for 0.5 s (inrush current)
Unit design	
Housing	Flush mounting DIN 43700/IEC 61554 Adaptable for rail mounting (recommended for local mounting only)
Dimensions (WxHxD) in mm	78.5 x 147 x 205.8 (incl. transparent cover and terminal blocks)
Weight (mass) approx.	1.5 kg
Degree of protection according to IEC 60529	
Housing Front Rear	 IP 51 IP 20
Protection of personnel	IP1X
U_L-listing	
Listed under “69CA”.	

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI C37.90.0/.1/.2; UL508 See also standards for individual tests
Insulation tests	
Standards	IEC 60255-5
Voltage test (routine test)	2.5 kV (r.m.s.), 50 Hz, 1 min
All circuits except for pulse output-earth	
Voltage test (type test) across open command contacts	 1.0 kV (r.m.s.), 50 Hz, 1 min
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses in intervals of 1 s

EMC tests for interference immunity; *type tests*	
Standards	IEC 60255-6, IEC 60255-22, EN 50263 (product standards) EN 50082-2 (generic standard) EN 61000-6-2 IEC 61000-4 (basic standards)
High-frequency test IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; R_i = 200 Ω; 400 surges/s; duration ≥2 s
Electrostatic discharge IEC 60255-22-2, class III EN 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, amplitude-modulated IEC 60255-22-3 and IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 %; 1 kHz; AM
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % 30 V/M; 1890 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst duration = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
High-energy surge voltage, IEC 61000-4-5 installation, class III Measuring inputs, binary outputs	Impulse: 1.2/50 µs Circuit groups to earth: 2 kV; 42 Ω, 0.5 µF Across circuit groups: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 60255-22-6 and IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 %; 1 kHz; R_i = 150 Ω
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous; 300 A/m for 5 s; 50 Hz 0.5 mT; 50 Hz
Damped wave IEC 60694, IEC 61000-4-12, class III	2.5 kV (peak, polarity alternating) 100 kHz, 1 MHz, 10 MHz and 50 MHz , R_i = 200 Ω, duration ≥ 2 s
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 Not across open contacts	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 shots per s; duration ≥ 2 s; R_i = 150 Ω to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	4 to 5 kV; 10/150 ns; 50 and 120 surges per ≥ 2 s; both polarities; duration ≥ 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz amplitude and pulse-modulated
EMC tests for interference emission; *type test*	
Standard	EN 50081–* (generic)
Interference field strength IEC CISPR 22	30 to 1000 MHz, class B

Technical data

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz ± 0.075 mm amplitude: 60 to 150 Hz; 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60225-21-2; class I	Semi-sinusoidal 5 *g* acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Seismic vibration IEC 60255-21-3; class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4.0 mm amplitude (horizontal vector) 1 to 8 Hz: ± 2.0 mm amplitude (vertical vector) 8 to 35 Hz: 1 *g* acceleration (horizontal vector) 8 to 35 Hz: 0.5 *g* acceleration (vertical vector) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transport (flush mounting)	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal 15 *g* acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal 10 *g* acceleration, duration 16 ms, each 1000 shocks in both directions of the 3 axes

Climatic stress tests

Temperatures

Temperatures during service	–20 °C to +70 °C / –4 °F to +158 °F With continuous current $2I_N$: –20 °C to +55 °C / –4 °F to +131 °F
Permissible temperature during storage	–25 °C to +55 °C / –13 °F to +131 °F
Permissible temperature during transport	–25 °C to +85 °C / –13 °F to +185 °F

Humidity

Permissible humidity class (standard)	Annual mean value ≤ 75 % relative humidity; on 30 days per year up to 95 % relative humidity; condensation not permissible.
Permissible humidity class (condensation proof)	Condensation is permissible according to IEC 60654-1, class III

Functions

Overcurrent protection

Definite time (DT O/C ANSI 50/51)

Setting range / steps	
Current pickup I>> (phases)	2 I_N to 20 I_N or deactivated, step 0.5 I_N
Current pickup I> (phases) 3-phase supply: see note*	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Current pickup I_E> 3-phase supply: see note*	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Delay times T_I>>	0 to 1575 ms, step 25 ms
Delay times T_I>	0 to 6300 ms, step 100 ms
The set time delays are pure delay times.	

Inverse time (IEC or ANSI 51)

Setting range / steps	
Current pickup I_p (phases) 3-phase supply: see note*	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Current pickup I_{Ep}> (earth calculated) 3-phase supply: see note*	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Delay times T_{Ip} (IEC)	0.05 to 3.15 s, step 0.05 s
Delay times D (ANSI)	0.5 to 15.00 s, step 0.25 s
Trip times	
Total time delay impulse output	Approx. 32 ms
Total time delay relay output	Approx. 38 ms
Reset ratio	Approx. 0.95 (with definite time) Approx. 0.91 (with inverse time)
Tolerances	
Definite time (DT O/C 50/51) Current pickup I>>, I>, I_E>	5 % of the set value or 5 % of I_N (at threshold < I_N)
Delay times T	1 % or 30 ms
Inverse time (IEC or ANSI 51) Pickup thresholds	5 % of the set value or 5 % of I_N (at threshold < I_N)
Time behavior for $2 \le I/I_p \le 20$	5 % or 50 ms
Deviation of the measured values as a result of various interferences	
Frequency in the range of $0.95 < f/f_N < 1.05$	< 2.5 %
Frequency in the range of $0.9 < f/f_N < 1.1$	< 10 %
Harmonics up to 10 % 3rd and 5th harmonic	< 1 %
DC components	< 5 %
Temperature in the range of – 5 °C to 70 °C / 23 °F to 158 °F	< 0.5 %/10 K

* Note: The device allows minimum setting values of 0.5 I_N (3-phase). With single supply, operation is ensured from 0.8 I_N (7SJ45XX-0*; pulse output) or 1.3 I_N (7SJ45XX-1*; relay output) onwards (printed on the front).

Technical data

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC).

This unit conforms to the international standard IEC 60255.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2.

Selection and ordering data

Description	Order No.
SIPROTEC easy 7SJ45 *numerical overcurrent protection relay powered by CTs*	*7SJ450□– □□□00 – □AA□*
Current transformer I_N	
1 A	*1*
5 A	*5*
Trip	
Pulse output (for further details refer to “Accessories”)	*0*
Relay output (for further details refer to “Accessories”)	*1*
Unit design	
For rail mounting	*B*
For panel flush mounting	*E*
Region-specific functions	
Region World, 50/60 Hz; standard	*A*
Region World, 50/60 Hz; condensation-proof	*B*
IEC / ANSI	
IEC	*0*
ANSI	*1*
Indication (flag)	
Without	*0*
With	*1*

Accessories

Protection relay with pulse output	
Low energy trip release	*3AX1104-2B*
Protection relay with relay output	
Auxiliary transformers for the trip circuit (30 VA CTs recommended)	
1 A	*4AM5065-2CB00-0AN2*
5 A	*4AM5070-8AB00-0AN2*
Current transformer-operated trip release	
0.5 A (rated operating current)	*3AX1102-2A*
1 A (rated operating current)	*3AX1102-2B*

SIPROTEC easy 7SJ46
Numerical Overcurrent Protection Relay

Fig. 5/11 SIPROTEC easy 7SJ46 numerical overcurrent protection relay

Description

The SIPROTEC easy 7SJ46 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks. It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The 7SJ46 relay has an AC and DC auxiliary power supply with a wide range allowing a high degree of flexibility in its application.

Function overview

- Universal application due to integrated wide range AC/DC power supply.
- Standard current transformers (1 A/5 A)
- Easy mounting due to compact housing
- Easy connection via screw-type terminals

Protection functions

- 2-stage overcurrent protection
- Definite-time and inverse-time characteristics (IEC/ANSI)
- High-current stage $I>>$ or calculated earth-current stage $I_E>$ or $I_{Ep}>$ selectable
- Two command outputs for “trip” or “pickup”
- Combination with electromechanical relays is possible due to the emulation algorithm

Monitoring functions

- One live contact for monitoring
- Hardware and software are continuously monitored during operation

Front design

- Simple setting via DIP switches (self-explaining)
- Settings can be executed without auxiliary voltage – no PC
- Individual phase pickup indication with stored or not stored LEDs
- Trip indication with separate LED

Additional features

- Optional version available for most adverse environmental conditions (condensation permissible)
- Flush mounting or surface (rail) mounting

5

Application

The SIPROTEC easy 7SJ46 is a numerical overcurrent protection relay which is primarily intended as a radial feeder or transformer protection (backup) in electrical networks.
It provides definite-time and inverse-time overcurrent protection according to IEC and ANSI standards. The convenient setting with DIP switches is self-explanatory and simple.

The 7SJ46 relay has an AC and DC auxiliary power supply with a wide range allowing a high degree of flexibility in its application. Phase-selective indication of protection pickup is indicated with LEDs.

ANSI	IEC	Protection functions
50	I>>	Instantaneous overcurrent protection
50, 51	I>t, I_p	Time-overcurrent protection (phase)
50N, 51N	I_E>t, I_{Ep}	Time-overcurrent protection (earth)

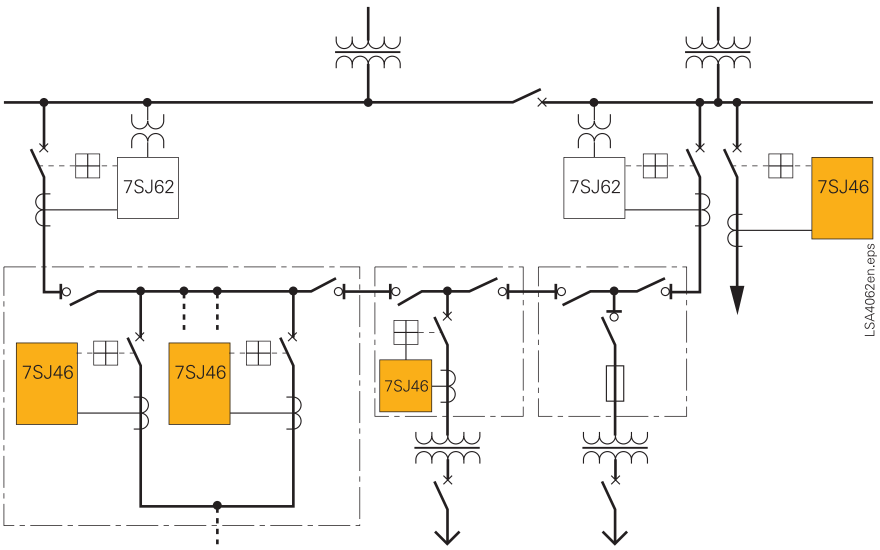


Fig. 5/12 Typical application

Fig. 5/13 Application in distribution switchgear

Construction

Within its compact housing the protection relay contains all required components for:

- Measuring and processing
- Pickup and command output
- Operation and indication (without a PC)
- Wide range AC/DC power supply
- Maintenance not necessary (no battery)

The housing dimensions of the units are such that the 7SJ46 relays can in general be installed into the existing panel cutouts. Alternative constructions are available (rail mounting and flush mounting). The compact housing permits easy mounting, and a version for the most adverse environmental conditions, even with extreme humidity, is also available.

Fig. 5/14 Screw-type terminals

Protection functions

The overcurrent function is based on phase-selective measurement of the three phase currents.

The earth (ground) current I_E (Gnd) is calculated from the three line currents I_{L1} (A), I_{L2} (B), and I_{L3} (C).

The relay has always a normal stage for phase currents $I>$ (50/51).

For the second stage, the user can choose between a high-current stage for phase currents $I>>$ (50) or a normal stage for calculated earth currents $I_E>$ (50N/51N).

The inverse-time overcurrent protection with integrating measurement method (disk emulation) emulates the behavior of electromechanical relays.

The influence of high frequency transients and transient DC components is largely suppressed by the implementation of numerical measured-value processing.

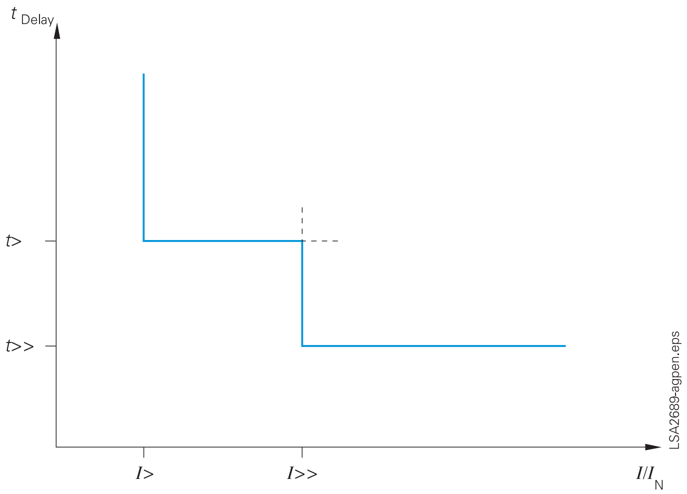


Fig. 5/15 Definite-time overcurrent characteristic

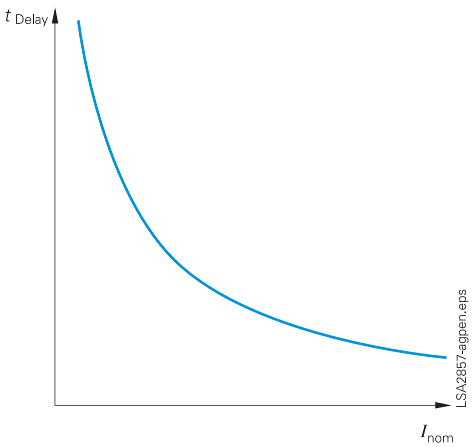


Fig. 5/16
Inverse-time overcurrent characteristic

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Moderately inverse/normal inverse	•	•
Very inverse	•	•
Extremely inverse	•	•

Connection diagrams

The 7SJ46 has a trip contact, a contact which is adjustable for trip or pickup, and a live contact for the self-monitoring function.

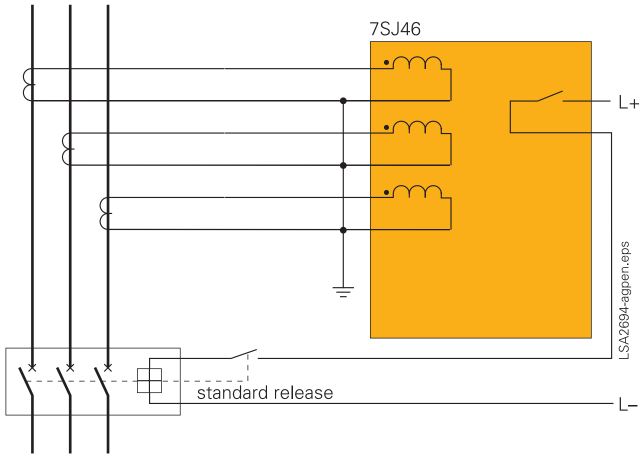


Fig. 5/17 Connection of 3 CTs

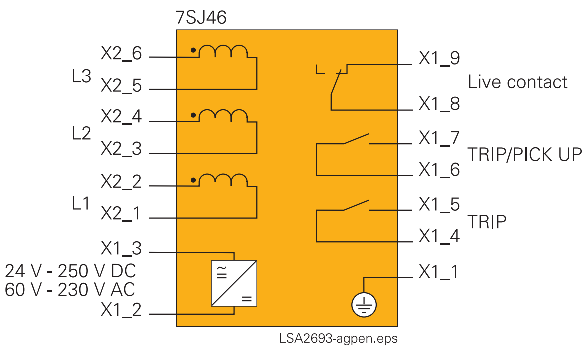


Fig. 5/18 Connection diagram 7SJ46

Technical data

General unit data	
Analog input	
System frequency f_N	50 or 60 Hz (selectable)
Current transformer inputs	
Rated current, normal earth current I_N	1 or 5 A
Power consumption	
Per phase at I_N = 1 A	Approx. 0.01 VA at I_N
Per phase at I_N = 5 A	Approx. 0.2 VA at I_N (relay)
Rating of current transformer circuit	
Thermal (r.m.s.)	100 · I_N for 1 s 30 · I_N for 10 s 4 · I_N continuous
Dynamic (peak)	250 · I_N for half a cycle
Auxiliary voltage AC/DC powered	
Input voltage range	24 to 250 V DC (± 20 %) 60 to 230 V AC (–20 %, +15 %)
Power consumption	DC – power supply: Approx. 1.5 W AC – power supply: Approx. 3 VA at 110 V approx. 5.5 VA at 230 V
Output relays	
Number	2 (normally open), 1 live contact
Contact rating	Make 1000 W/VA Break 30 VA 40 W resistive 25 VA at L/R ≤ 50 ms
Rated contact voltage	≤ 250 V DC or ≤ 240 V AC
Permissible current per contact	5 A continuous 30 A for 0.5 s (inrush current)
Unit design	
Housing	Flush mounting DIN 43700/IEC 61554 Adaptable for rail mounting recommended for local mounting only
Dimensions (WxHxD) in mm	78.5 x 147 x 205.8 (incl. transparent cover and terminal blocks)
Weight (mass) approx.	1 kg
Degree of protection according to IEC 60529	
Housing	
Front	IP 51
Rear	IP 20
Protection of personnel	IP 1X
U_L-listing	
Listed under "69CA".	

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI C37.90.0/.1/.2; UL508 See also standards for individual tests
Insulation tests	
Standards	IEC 60255-5
Voltage test (routine test) all circuits except auxiliary supply	2.5 kV (r.m.s.), 50 Hz; 1 min
Voltage test (routine test) auxiliary supply	3.5 kV DC; 30 s; both polarities
Voltage test (type test)	
Across open contacts	1.5 kV (r.m.s.), 50 Hz; 1 min
Across open live contact	1.0 kV (r.m.s.), 50 Hz; 1 min
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses in intervals of 1 s
EMC tests for interference immunity; type tests	
Standards	IEC 60255-6, IEC 60255-22, EN 50263 (product standards) EN 50082-2 (generic standard) EN 61000-6-2 IEC 61000-4 (generic standards)
High-frequency tests IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; R_i = 200 Ω; 400 surges/s; duration ≥ 2 s
Electrostatic discharge IEC 60255-22-2, class III EN 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, amplitude-modulated IEC 60255-22-3 and IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 %; 1 kHz; AM
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % 30 V/m 1810 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
High-energy surge voltage, IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary voltage	circuit groups to earth: 2 kV; 12 Ω, 9 µF between circuit groups: 1 kV; 2 Ω, 18 µF
Measuring inputs, binary outputs	circuit groups to earth: 2 kV; 42 Ω, 0.5 µF between circuit groups: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated. IEC 60255-22-6 and IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 %; 1 kHz; AM; R_i = 150 Ω
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous; 300 A/m for 5 s; 50 Hz 0.5 mT; 50 Hz
Damped wave IEC 60694, IEC 61000-4-12, class III	2.5 kV (peak, polarity alternating) 100 kHz, 1 MHz, 10 MHz and 50 MHz , R_i = 200 Ω, duration ≥ 2 s
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 shots per s; duration ≥ 2 s; R_i = 150 Ω to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 not across open contacts	4 kV to 5 kV; 10/150 ns; 50 and 120 surges per s; both polarities; duration ≥ 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m 25 MHz to 1000 MHz amplitude and pulse-modulated
EMC tests for interference emission; type test	
Standard	EN 50081–* (generic)
Conducted interference voltage, auxiliary voltage IEC CISPR 22, EN 55022, DIN EN VDE 0878 Part 22	150 kHz to 30 MHz, class B
Interference field strength IEC CISPR 22	30 MHz to 1000 MHz, class B

Technical data

Mechanical stress test

Vibration, shock and seismic vibration

During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60225-21-2; class I	Semi-sinusoidal 5 *g* acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Seismic vibration IEC 60255-21-3; class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4.0 mm amplitude (horizontal vector) 1 to 8 Hz: ± 2.0 mm amplitude (vertical vector) 8 to 35 Hz: 1 *g* acceleration (horizontal vector) 8 to 35 Hz: 0.5 *g* acceleration (vertical vector) Frequeny sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transport (flush mounting)	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ± 7.5 mm amplitude; 8 Hz to 150 Hz: 2 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal 15 *g* acceleration, duration 11 ms, each 3 shocks in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal 10 *g* acceleration, duration 16 ms, each 1000 shocks in both directions of the 3 axes

Climatic stress tests

Temperatures

Temperatures during service	–20 °C to +70 °C / –4 °F to +158 °F with continuous current 4 I_N: –20 °C to +55 °C / –4 °F to +131 °F
Maximum temperature during storage	–25 °C to +55 °C / –13 °F to +131 °F
Maximum temperature during transport	–25 °C to +85 °C / –13 °F to +185 °F

Humidity

Permissible humidity class (standard)	Annual mean value ≤ 75 % relative humidity; on 30 days per year up to 95 % relative humidity; condensation not permissible.
Permissible humidity class (condensation proof)	Condensation is permissible according to IEC 60654-1, class III

Functions

Overcurrent protection

Definite time (DT O/C ANSI 50/51)	
Setting range / steps	
Current pickup I>> (phases)	2 I_N to 20 I_N or deactivated, step 0.5 I_N
Current pickup I> (phases)	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Current pickup I_E> (earth calculated)	0.5 I_N to 6.2 I_N or deactivated, step 0.1 I_N
Delay times T_I>>	0 to 1575 ms, step 25 ms
Delay times T_I>	0 to 6300 ms, step 100 ms
The set time delays are pure delay times.	
Inverse time (IEC or ANSI 51)	
Current pickup I_p (phases)	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Current pickup I_{Ep}> (earth calculated)	0.5 I_N to 4 I_N or deactivated, step 0.1 I_N
Delay times T_{Ip} (IEC)	0.05 to 3.15 s, step 0.05 s
Delay times D (ANSI)	0.5 to 15.00 s, step 0.25 s
Trip times	
Switch on to fault, relay output	Approx. 38 ms
Reset ratio	Approx. 0.95 (with definite time) Approx. 0.91 (with inverse time)
Tolerances	
Definite time (DT O/C 50/51) Current pickup I>>, I>, I_E>	5 % of the set value or 5 % of I_N (at threshold < I_N)
Delay times T	1 % or 30 ms
Inverse time (IEC or ANSI 51) Pickup thresholds	5 % of the set value or 5 % of I_N (at threshold < I_N)
Time behaviour for 2 ≤ I/I_p ≤ 20	5 % or 50 ms
Deviation of the measured values as a result of various interferences	
Frequency in the range of 0.95 < f/f_N < 1.05	< 2.5 %
Frequency in the range of 0.9 < f/f_N < 1.1	< 10 %
Harmonics up to 10 % 3rd and 5th harmonic	< 1 %
DC components	< 5 %
Auxiliary supply voltage DC in the range of 0.8 ≤ $V_{aux}/V_{aux\,N}$ ≤ 1.2	< 1 %
Auxiliary supply voltage AC in the range of 0.8 ≤ $V_{aux}/V_{aux\,N}$ ≤ 1.15	< 1 %
Temperature in the range of –5 °C to 70 °C / 23 °F to 158 °F	< 0.5 %/10 K

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC).

This unit conforms to the international standard IEC 60255.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2.

Selection and ordering data

Description	Order No.
SIPROTEC easy 7SJ46	
numerical overcurrent protection relay	*7SJ460□ – 1□□00 – □AA0*
Current transformer I_N	
1 A	*1*
5 A	*5*
Unit design	
For rail mounting	*B*
For panel-flush mounting	*E*
Region-specific/functions	
Region World, 50/60 Hz; standard	*A*
Region World, 50/60 Hz; condensation-proof	*B*
IEC / ANSI	
IEC	*0*
ANSI	*1*

SIPROTEC 7SJ600
Numerical Overcurrent, Motor and Overload Protection Relay

Fig. 5/19 SIPROTEC 7SJ600
numerical overcurrent, motor and overload protection relay

Description

The SIPROTEC 7SJ600 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ600 provides definite-time and inverse-time overcurrent protection along with overload and negative-sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

Function overview

Feeder protection

- Overcurrent-time protection
- Earth-fault protection
- Overload protection
- Negative-sequence protection
- Cold load pickup
- Auto-reclosure
- Trip circuit supervision

Motor protection

- Starting time supervision
- Locked rotor

Control functions

- Commands for control of a circuit-breaker
- Control via keyboard, DIGSI 4 or SCADA system

Measuring functions

- Operational measured values I

Monitoring functions

- Fault event logging with time stamp (buffered)
- 8 oscillographic fault records
- Continuous self-monitoring

Communication

- Via personal computer and DIGSI 3 or DIGSI 4 (≥ 4.3)
- Via RS232 – RS485 converter
- Via modem
- IEC 60870-5-103 protocol, 2 kV-isolated
- RS485 interface

Hardware

- 3 current transformers
- 3 binary inputs
- 3 output relays
- 1 live status contact

5

Application

Wide range of applications

The SIPROTEC 7SJ600 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ600 provides definite-time and inverse-time overcurrent protection along with overload and negative-sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

The integrated control function allows simple control of a circuit-breaker or disconnector (electrically operated/motorized switch) via the integrated HMI, DIGSI 3 or DIGSI 4 (≥ 4.3) or SCADA (IEC 60870-5-103 protocol).

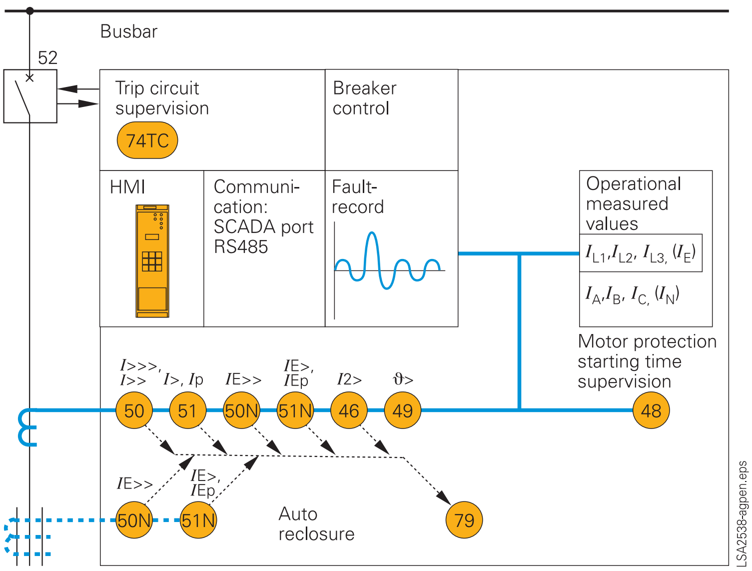


Fig. 5/20 Function diagram

ANSI	IEC	Protection functions
50, 50N	I>, I>>, I>>> I_E>, I_E>>	Definite time-overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse time-overcurrent protection (phase/neutral)
79		Auto-reclosure
46	I_2>	Phase-balance current protection (negative-sequence protection)
49	ϑ>	Thermal overload protection
48		Starting time supervision
74TC		Trip circuit supervision breaker control

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485)
- Power supply.

The rated CT currents applied to the SIPROTEC 7SJ600 can be 1 or 5 A. This is selectable via a jumper inside the relay.

Two different housings are available. The flush-mounting/cubicle-mounting version has terminals accessible from the rear. The surface-mounting version has terminals accessible from the front.

Fig. 5/21
Rear view of flush-mounting housing

Protection functions

Definite-time characteristics

The definite-time overcurrent function is based on phase-selective measurement of the three phase currents and/or earth current.

Optionally, the earth (ground) current I_E (Gnd) is calculated or measured from the three line currents $I_{L1}(I_A)$, $I_{L2}(I_B)$ and $I_{L3}(I_C)$.

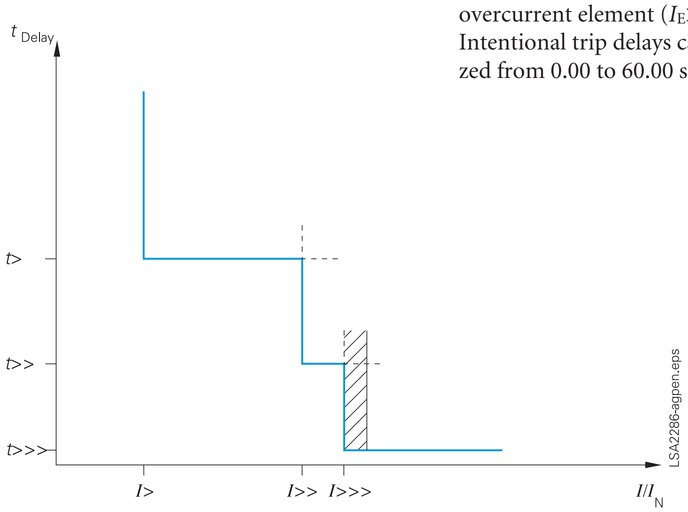


Fig. 5/22 Definite-time overcurrent characteristic

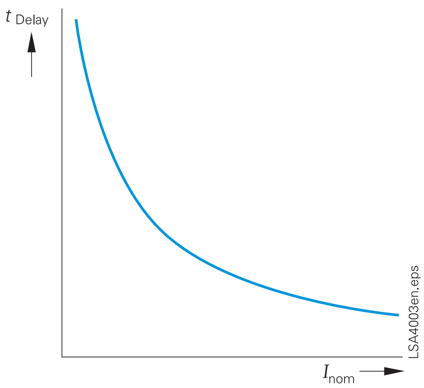


Fig. 5/23
Inverse-time overcurrent characteristic

The definite-time overcurrent protection for the 3 phase currents has a low-set overcurrent element (*I*>), a high-set overcurrent element (*I*>>) and a high-set instantaneous-tripping element (*I*>>>). Intentional trip delays can be parameterized from 0.00 to 60.00 seconds for the low-set and high-set overcurrent elements. The instantaneous zone *I*>>> trips without any intentional delay. The definite-time overcurrent protection for the earth (ground) current has a low-set overcurrent element (I_E>) and a high-set overcurrent element (I_E>>).
Intentional trip delays can be parameterized from 0.00 to 60.00 seconds.

Inverse-time characteristics

In addition, invese-time overcurrent protection characteristics (IDMTL) can be activated.

Available inverse-time characteristic

Characteristics acc.to	ANSI / IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	
I squared *T*	•	

Protection functions

Thermal overload protection (ANSI 49)

The thermal overload protection function provides tripping or alarming based on a thermal model calculated from phase currents.

Thermal overload protection without preload

For thermal overload protection without consideration of the preload current, the following tripping characteristic applies only when

$I \geq 1.1 \cdot I_L$

For different thermal time constants T_L, the tripping time t is calculated in accordance with the following equation:

$$t = \frac{35}{\left(\frac{I}{I_L}\right)^2 - 1} \cdot T_L$$

$I =$ Load current

$I_2 =$ Pickup current

$T_L =$ Time multiplier

The reset threshold is above $1.03125 \cdot I/I_N$

Thermal overload protection with preload

The thermal overload protection with consideration of preload current constantly updates the thermal model calculation regardless of the magnitude of the phase currents. The tripping time t is calculated in accordance with the following tripping characteristic (complete memory in accordance with IEC 60255-8).

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

t = Tripping time after beginning of the thermal overload

$\tau = 35.5 \cdot T_L$

I_{pre} = Pre-load current

T_L = Time multiplier

I = Load current

k = k factor (in accordance with IEC 60255-8)

ln = Natural logarithm

I_N = Rated (nominal) current

For further details please refer to part 2 “Overview”.

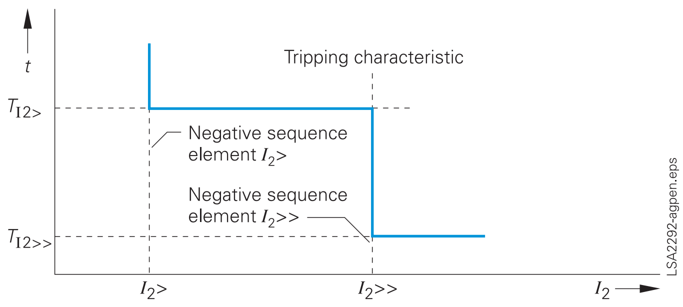


Fig. 5/24 Tripping characteristic of the negative-sequence protection function

Negative-sequence protection ($I_2>>$, $I_2>$/ANSI 46 Unbalanced-load protection)

The negative-sequence protection (see Fig. 5/24) detects a phase failure or load unbalance due to network asymmetry. Interruptions, short-circuits or crossed connections to the current transformers are detected.

Furthermore, low level single-phase and two-phase short-circuits (such as faults beyond a transformer) as well as phase interruptions can be detected.

This function is especially useful for motors since negative sequence currents cause impermissible overheating of the rotor.

In order to detect the unbalanced load, the ratio of negative phase-sequence current to rated current is evaluated.

I_2 = Negative-sequence current
T_{12} = Tripping time

Transformer protection

The high-set element permits current coordination where the overcurrent element functions as a backup for the lower-level protection relays, and the overload function protects the transformer from thermal overload. Low-current single-phase faults on the low voltage side that result in negative phase-sequence current on the high-voltage side can be detected with the negative-sequence protection.

Cold load pickup

By means of a binary input which can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable duration of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady state conditions.

3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase auto-reclosing of a feeder which has previously been disconnected by time-overcurrent protection.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for the trip circuit monitoring.

Control

The relay permits circuit-breakers to be opened and closed without command feedback. The circuit-breaker/disconnector may be controlled by DIGSI, or by the integrated HMI, or by the LSA/SCADA equipment connected to the interface.

Protection functions

Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker bypassing the internal control function, manual detection using a binary input is implemented.

Busbar protection (Reverse interlocking)

Binary inputs can be used to block any of the six current stages. Parameters are assigned to decide whether the input circuit is to operate in open-circuit or closed-circuit mode. In this case, reverse interlocking provides high-speed busbar protection in radial or ring power systems that are opened at one point. The reverse interlocking principle is used, for example, in medium-voltage power systems and in switchgear for power plants, where a high-voltage system transformer feeds a busbar section with several medium-voltage outgoing feeders.

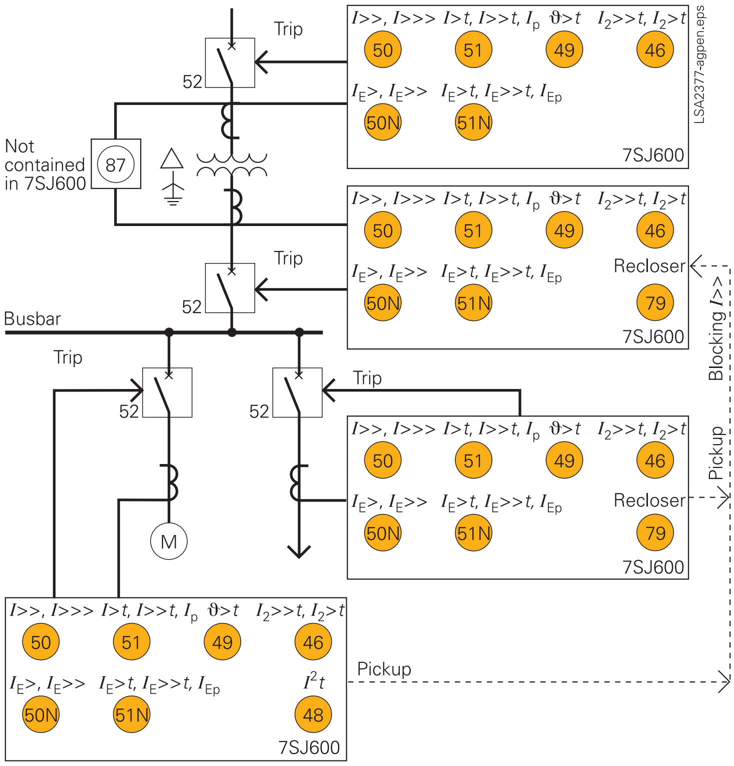


Fig. 5/25 Reverse interlocking

Motor protection

For short-circuit protection, e.g. elements $I>>$ (50) and I_E (50N) are available. The stator is protected against thermal overload by $\vartheta_s>$ (49), the rotor by $I_2>$ (46), starting time supervision (48).

Motor starting time supervision (ANSI 48)

The start-up monitor protects the motor against excessively long starting. This can occur, for example, if the rotor is blocked, if excessive voltage drops occur when the motor is switched on or if excessive load torques occur. The tripping time depends on the current.

$$t_{TRIP} = \left(\frac{I_{start}}{I_{rms}}\right)^2 \cdot t_{start\,max}$$

for $I_{rms} > I_{start}$, reset ratio $\frac{I_N}{I_{start}}$

approx. 0.94

t_{TRIP} = Tripping time

I_{start} = Start-up current of the motor

$t_{start\,max}$ = Maximum permissible starting time

I_{rms} = Actual current flowing

Features

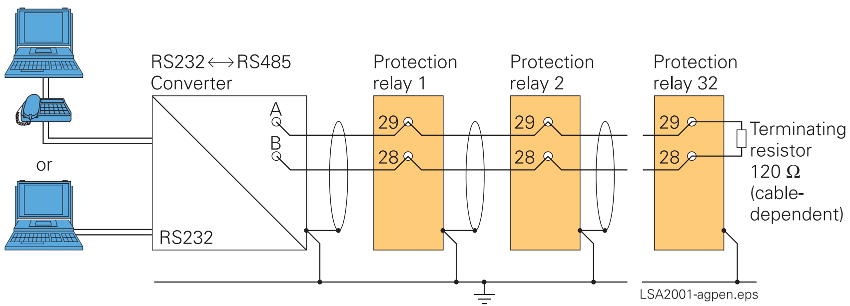


Fig. 5/26 Wiring communication
For convenient wiring of the RS485 bus, use bus cable system 7XV5103 (see part 14 of this catalog).

Serial data transmission

A PC can be connected to ease setup of the relay using the Windows-based program DIGSI which runs under MS-Windows. It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and 1 event log containing up to 30 operational indications. The SIPROTEC 7SJ600 transmits a subset of data via IEC 60870-5-103 protocol:

- General fault detection
- General trip
- Phase current I_{L2}
- User-defined message
- Breaker control
- Oscillographic fault recording

Connection diagrams

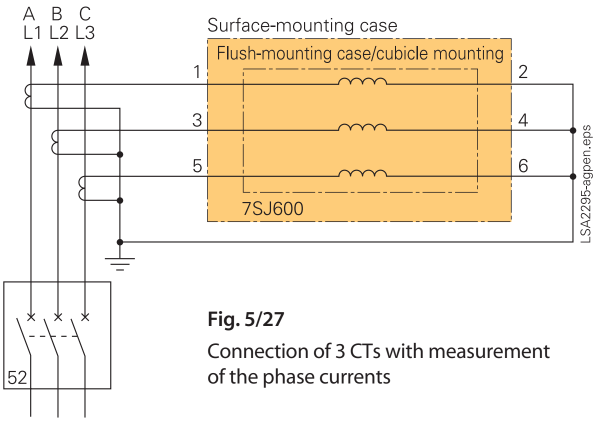


Fig. 5/27
Connection of 3 CTs with measurement of the phase currents

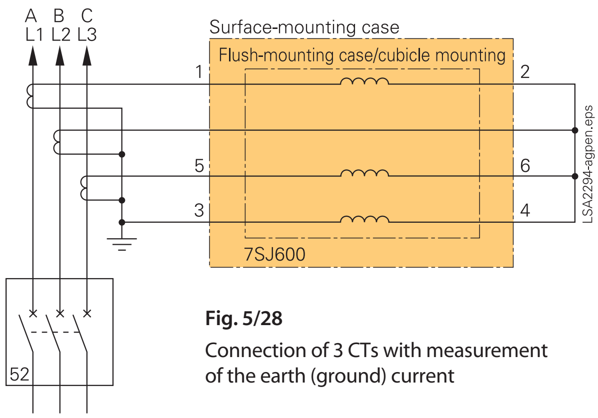


Fig. 5/28
Connection of 3 CTs with measurement of the earth (ground) current

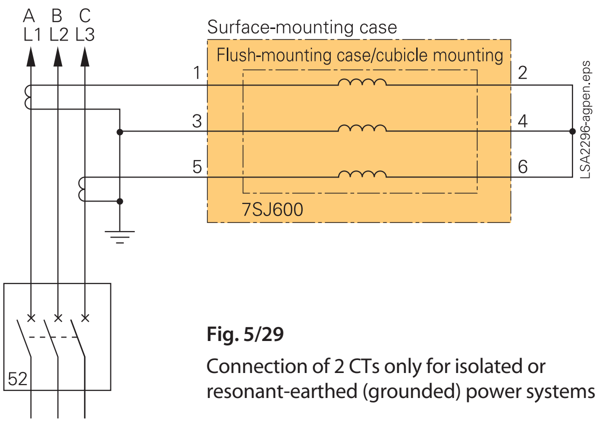


Fig. 5/29
Connection of 2 CTs only for isolated or resonant-earthed (grounded) power systems

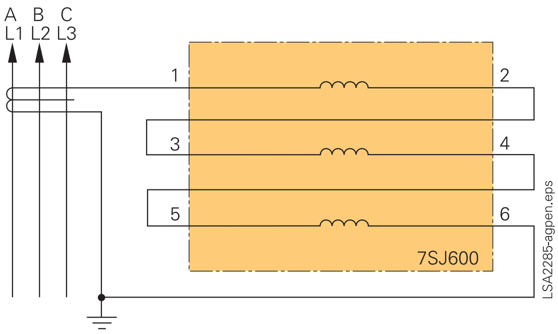


Fig. 5/30
Sensitive earth-fault protection
(3 -times increased sensitivity)

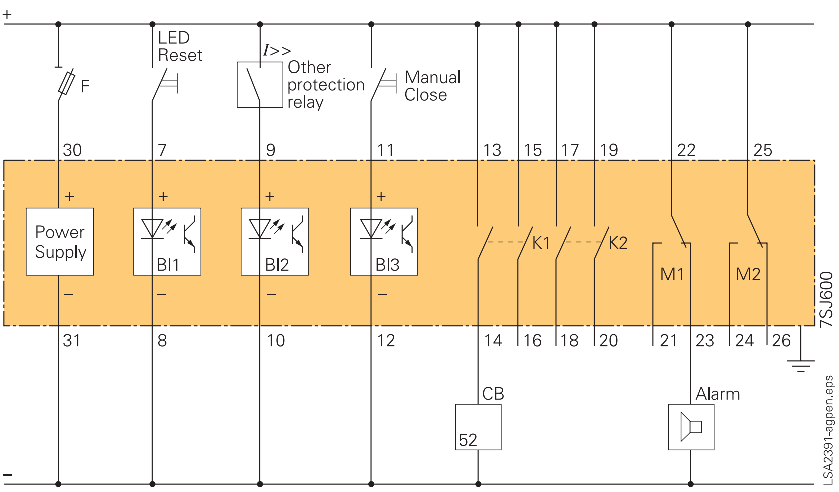


Fig. 5/31 Example of typical wiring

Technical data

General unit data	
CT circuits	
Rated current I_N	1 or 5 A
Rated frequency f_N	50/60 Hz (selectable)
Overload capability current path Thermal (r.m.s.) Dynamic (pulse current)	 100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous 250 x I_N one half cycle
Power consumption Current input at I_N = 1 A at I_N = 5 A	 < 0.1 VA < 0.2 VA
Power supply via integrated DC/DC converter	
Rated auxiliary voltage V_{aux} / permissible variations	24, 48 V DC/± 20 % 60, 110/125 V DC/± 20 % 220, 250 V DC/± 20 % 115 V AC/–20 % +15 % 230 V AC/–20 % +15 %
Superimposed AC voltage, peak-to-peak at rated voltage at limits of admissible voltage	 ≤ 12 % ≤ 6 %
Power consumption Quiescent Energized	 Approx. 2 W Approx. 4 W
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms at V_{aux} ≥ 110 V DC ≥ 20 ms at V_{aux} ≥ 24 V DC
Binary inputs	
Number	3 (marshallable)
Operating voltage	24 to 250 V DC
Current consumption, independent of operating voltage	Approx. 2.5 mA
Pickup threshold, reconnectable by solder bridges Rated aux. voltage 24/48/60 V DC V_{pickup} $V_{drop\text{-}out}$ 110/125/220/250 V DC V_{pickup} $V_{drop\text{-}out}$	 ≥ 17 V DC < 8 V DC ≥ 74 V DC < 45 V DC
Signal contacts	
Signal/alarm relays	2 (marshallable)
Contacts per relay	1 CO
Switching capacity Make Break	 1000 W / VA 30 W / VA
Switching voltage	250 V
Permissible current	5 A

Heavy-duty (command) contacts	
Trip relays, number	2 (marshallable)
Contacts per relay	2 NO
Switching capacity Make Break	 1000 W / VA 30 W / VA
Switching voltage	250 V
Permissible current Continuous For 0.5 s	 5 A 30 A
Design	
Housing 7XP20	Refer to part 16 for dimension drawings
Weight Flush mounting /cubicle mounting Surface mounting	 Approx. 4 kg Approx. 4.5 kg
Degree of protection acc. to EN 60529 Housing Terminals	 IP51 IP21

Serial interface	
Interface, serial; isolated	
Standard	RS485
Test voltage	2.8 kV DC for 1 min
Connection	Data cable at housing terminals, two data wires, one frame reference, for connection of a personal computer or similar; core pairs with individual and common screening, screen must be earthed (grounded), communication possible via modem
Transmission speed	As delivered 9600 baud min. 1200 baud, max. 19200 baud

Electrical tests	
Specifications	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Insulation test	
Standards	IEC 60255-5, ANSI/IEEE C37.90.0
High-voltage test (routine test) Except DC voltage supply input and RS485 Only DC voltage supply input and RS485	 2 kV (r.m.s.), 50 Hz 2.8 kV DC
High-voltage test (type test) Between open contacts of trip relays Between open contacts of alarm relays	 1.5 kV (r.m.s.), 50 Hz 1 kV (r.m.s.), 50 Hz
Impulse voltage test (type test) all circuits, class III	5 kV (peak), 1.2/50 µs, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s

Technical data

EMC tests for interference immunity; type tests	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic standard), DIN VDE 0435 Part 303
High-frequency test IEC 60255-22-1, class III	2.5 kV (peak), 1 MHz, τ = 15 µs, 400 surges/s, duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge, 8 kV air discharge, both polarities, 150 pF, R_i=330 Ω
Irradiation with radio-frequency field	
Non-modulated, IEC 60255-22-3 (report) class III	10 V/m, 27 to 500 MHz
Amplitude modulated, IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, 80 % AM, 1 kHz
Pulse modulated, IEC 61000-4-3, class III	10 V/m, 900 MHz, repetition frequency, 200 Hz, duty cycle 50 %
Fast transient interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV, 5/50 ns, 5 kHz, burst length 15 ms, repetition rate 300 ms, both polarities, R_i = 50 Ω, duration 1 min
Conducted disturbances induced by radio-frequency fields, amplitude modulated IEC 601000-4-6, class III	10 V, 150 kHz to 80 MHz, 80 % AM, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous, 50 Hz 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak), 1 MHz to 1.5 MHz, decaying oscillation, 50 shots per s, duration 2 s, R_i = 150 Ω to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (commom mode)	4 to 5 kV, 10/150 ns, 50 surges per s, both polarities, duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference, ANSI/IEEE C37.90.2	10 to 20 V/m, 25 to 1000 MHz, amplitude and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity), 100 kHz, 1 MHz, 10 MHz and 50 MHz, decaying oscillation, R_i = 50 Ω
EMC tests for interference emission; *type tests*	
Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage CISPR 22, EN 55022, DIN VDE 0878 Part 22, limit value class B	150 kHz to 30 MHz
Interference field strength CISPR 11, EN 55011, DIN VDE 0875 Part 11, limit value class A	30 to 1000 MHz

Mechanical stress tests	
Vibration, shock and seismic vibration	
During operation	
Standards	Acc. to IEC 60255-2-1 and IEC 60068-2
Vibration IEC 60255-21-1, class1 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude, 60 to 150 Hz: 0.5 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1	Half-sine, acceleration 5 *g*, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class 1, IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sine, acceleration 15 *g*, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sine, acceleration 10 *g* duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests	
Temperatures	
Recommended temperature during operation	–5 °C to +55 °C / +23 °F to +131 °F > 55 °C decreased display contrast
Permissible temperature	
during operation	–20 °C to +70 °C / –4 °F to +158 °F
during storage	–25 °C to +55 °C / –13 °F to +131 °F
during transport	–25 °C to +70 °C / –13 °F to +158 °F
(Storage and transport with standard works packaging)	
Humidity	
	Mean value per year ≤ 75 % relative humidity, on 30 days per year 95 % relative humidity, condensation not permissible

Technical data

Functions

Definite-time overcurrent protection *(ANSI 50, 50N)*	
Setting range/steps	
Overcurrent pickup phase $I>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
earth $I_E>$	= 0.05 to 25 (steps 0.01), or ∞
phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
earth $I_E>>$	= 0.05 to 25 (steps 0.01), or ∞
phase $I>>>$	I/I_N = 0.3 to 12.5 (steps 0.1), or ∞
Delay times T for $I>$, $I_E>$, $I>>$ and $I_E>>$	0 s to 60 s (steps 0.01 s)
The set times are pure delay times	
Pickup times $I>$, $I>>$, $I_E>$, $I_E>>$	
At 2 x setting value, without meas. repetition	Approx. 35 ms
At 2 x setting value, with meas. repetition	Approx. 50 ms
Pickup times for $I>>>$ at 2 x setting value	Approx. 20 ms
Reset times $I>$, $I>>$, $I_E>$, $I_E>$	Approx. 35 ms
$I>>>$	Approx. 65 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 25 ms
Tolerances	
Pickup values $I>$, $I>>$, $I>>>$, $I_E>$, $I_E>>$	5 % of setting value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $0\ °C \leq \Theta_{amb} \leq 40\ °C$	≤ 0.5 %/10 K
Frequency, range: $0.98 \leq f/f_N \leq 1.02$	≤ 1.5 %
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 2.5 %
Harmonics	
Up to 10 % of 3rd harmonic	≤ 1 %
Up to 10 % of 5th harmonic	≤ 1 %
Inverse-time overcurrent protection *(ANSI 51/51N)*	
Setting range/steps	
Overcurrent pickup phase I_p	I/I_N = 0.1 to 4 (steps 0.1)
earth I_{Ep}	= 0.05 to 4 (steps 0.01)
Time multiplier for I_p, I_{Ep} T_p	(IEC charac.) 0.05 to 3.2 s (steps 0.01 s) (ANSI charac.) 0.5 to 15 s (steps 0.1 s)
Overcurrent pickup phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1), or ∞
phase $I>>>$	= 0.3 to 12.5 (steps 0.1), or ∞
earth $I_E>>$	= 0.05 to 25 (steps 0.01), or ∞
Delay time T for $I>>$, $I_E>>$	0 s to 60 s (steps 0.01 s)
Tripping time characteristics acc. to IEC	
Pickup threshold	Approx. 1.1 x I_p
Drop-out threshold	Approx. 1.03 x I_p
Drop-out time	Approx. 35 ms
Tripping time characteristics acc. to ANSI / IEEE	
Pickup threshold	Approx. 1.06 x I_p
Drop-out threshold, alternatively: disk emulation	Approx. 1.03 x I_p

Tolerances			
Pickup values	5 %		
Delay time for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_N \leq 24$	5 % of theoretical value ± 2 % current tolerance, at least 30 ms		
Influencing variables			
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %		
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ $+23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K		
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 % referred to theoretical time value		
Negative-sequence overcurrent protection *(ANSI 46)*			
Setting range/steps			
Tripping stage $I_2>$ in steps of 1 %	8 % to 80 % of I_N		
$I_2>>$ in steps of 1 %	8 % to 80 % of I_N		
Time delays $T(I_2>)$, $T(I_2>>)$ in steps of 0.01s	0.00 s to 60.00 s		
Lower function limit	At least one phase current ≥ 0.1 x I_N		
Pickup times	At f_N =	50 Hz	60 Hz
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx.	60 ms	75 ms
But with currents I/I_N>1.5 (overcurrent case) or negative-sequence current < (set value +0.1 x I_N)	Approx.	200 ms	310 ms
Reset times	At f_N =	50 Hz	60 Hz
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx.	35 ms	42 ms
Reset ratios			
Tripping stage $I_2>$, tripping stage $I_2>>$	Approx. 0.95 to 0.01 x I_N		
Tolerances			
Pickup values $I_2>$, $I_2>>$			
with current $I/I_N \leq 1.5$	± 1 % of I_N ± 5 % of set value		
with current $I/I_N > 1.5$	± 5 % of I_N ± 5 % of set value		
Stage delay times	± 1 % or 10 ms		
Influence variables			
Auxiliary DC voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %		
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq +40\ °C$ $+23\ °F \leq \Theta_{amb} \leq +104\ °F$	≤ 0.5 %/10 K		
Frequency,			
range: $0.98 \leq f/f_N \leq 1.02$	≤ 2 % of I_N		
range: $0.95 \leq f/f_N \leq 1.05$	≤ 5 % of I_N		
Auto-reclosure (option) *(ANSI 79)*			
Number of possible shots	1 up to 9		
Auto-reclose modes	3-pole		
Dead times for 1st to 3rd shot	0.05 s to 1800 s (steps 0.01 s)		
for 4th and any further shot	0.05 s to 1800 s (steps 0.01 s)		
Reclaim time after successful AR	0.05 s to 320 s (steps 0.01 s)		
Lock-out time after unsuccessful AR	0.05 s to 320 s (steps 0.01 s)		
Reclaim time after manual close	0.50 s to 320 s (steps 0.01 s)		
Duration of RECLOSE command	0.01s to 60 s (steps 0.01 s)		
Control			
Number of devices	1		
Evaluation of breaker control	None		

Technical data

***Thermal overload protection with memory** (ANSI 49) (total memory according to IEC 60255-8)*	
Setting ranges	
Factor k acc. to IEC 60255-8	0.40 to 2 (steps 0.01)
Thermal time constant τ_{th}	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 99 % referred to trip temperature rise (steps 1 %)
Prolongation factor at motor stand-still k_τ	1 to 10 (steps 0.01)
Reset ratios	
Θ/Θ_{trip}	Reset below Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
Tolerances	
Referring to k · I_N	± 5 % (class 5 % acc. to IEC 60255-8)
Referring to trip time	± 5 % ± 2 s (class 5 % acc. to IEC 60255-8)
Influence variables referred to k · I_N	
Auxiliary DC voltage in the range of $0.8 \leq V_{aux} / V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq +40\ °C$ $+23\ °F \leq \Theta_{amb} \leq +104\ °F$	≤ 0.5 % / 10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Without pickup value I_L / I_N	0.4 to 4 (steps 0.1)
Memory time multiplier T_L (= t_6 -time)	1 to 120 s (steps 0,1 s)
Reset ratio I/I_L	Approx. 0.94
Tolerances	
Referring to pickup threshold 1.1· I_L	± 5 %
Referring to trip time	± 5 % ± 2 s
Influence variables	
Auxiliary DC voltage in the range of $0.8 \leq V_{aux} / V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq +40\ °C$ $+23\ °F \leq \Theta_{amb} \leq +104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 1 %

Starting time supervision (motor protection)	
Setting ranges	
Permissible starting current I_{Start}/I_N	0.4 to 20 (steps 0.1)
Permissible starting time t_{Start}	1 to 360 s (steps 0.1 s)
Tripping characteristic	$t = \left(\frac{I_{Start}}{I_{rms}}\right)^2 \cdot t$ for $I_{rms} > I_{Start}$
Reset ratio I_{rms} / I_{Start}	Approx. 0.94
Tolerances	
Pickup value	5 %
Delay time	5 % of setting value or 330 ms

Fault recording	
Measured values	I_{L1}, I_{L2}, I_{L3}
Start signal	Trip, start release, binary input
Fault storage	Max. 8 fault records
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, incl. 35 power-fail safe selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 to 5.00 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 to 0.50 s (steps 0.01s)
Post-fault time T_{post}	0.05 to 0.50 s (steps 0.01 s)
Sampling rate	1 instantaneous value per ms at 50 Hz 1 instantaneous value per 0.83 ms at 60 Hz

Additional functions	
Operational measured values	
Operating currents	I_{L1}, I_{L2}, I_{L3}
Measuring range	0 % to 240 % I_N
Tolerance	3 % of rated value
Thermal overload values	
Calculated temperature rise	Θ/Θ_{trip}
Measuring range	0 % to 300 %
Tolerance	5 % referred to Θ_{trip}
Fault event logging	
Storage of indications of the last 8 faults	
Time assignment	
Resolution for operational indications	1 s
Resolution for fault event indications	1 ms
Max. time deviation	0.01 %
Trip circuit supervision	
With one or two binary inputs	
Circuit-breaker trip test	
With live trip or trip/reclose cycle (version with auto-reclosure)	

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Selection and ordering data

Description	Order No.
7SJ600 numerical overcurrent, motor and overload protection relay Binary input voltage 24 to 250 V DC with isolated RS485 port	7SJ600□ – □□A□0 – □D□□
Rated current at 50/60 Hz	
1 A 1)	1
5 A 1)	5
Rated auxiliary voltage	
24, 48 V DC	2
60, 110, 125 V DC 2)	4
220, 250 V DC, 115 V AC 2)	5
230 V AC 3)	6
Unit design	
For panel surface mounting, terminals on the side	B
For panel flush mounting/cubicle mounting	E
Languages	
English, German, Spanish, French, Russian	0
Auto-reclosure (option)	
Without	0
With	1
Control	
Without	A
With	B
U_L-Listing	
Without U_L-listing	0
With U_L-listing	1

Accessories

Converter RS232 (V.24) - RS485*	
With communication cable for the 7SJ600 numerical overcurrent, motor and overload protection relay Length 1 m PC adapter	
With power supply unit 230 V AC	7XV5700- 0□□00 4)
With power supply unit 110 V AC	7XV5700- 1□□00 4)
Converter, full-duplex, fiber-optic cable RS485 with built-in power supply unit	
Auxiliary voltage 24 to 250 V DC and 110/230 V AC	7XV5650- 0BA00
Mounting rail for 19" rack	C73165-A63-C200-1
Manual for 7SJ600	
English	C53000-G1176-C106-7
Spanish	C53000-G1178-C106-1
French	C53000-G1177-C106-3
Sample order	
7SJ600, 1 A, 60 - 125 V, flush mounting, ARC	7SJ6001-4EA00-1DA0
Converter V.24 -RS485, 230 V AC	7XV5700-0AA00
Manual, English	C53000-G1176-C106-7

LSP2289-afp.eps

Mounting rail

1) Rated current can be selected by means of jumpers.
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
3) Only when position 16 is not "1" (with U_L-listing).
4) Possible versions see part 14.
* RS485 bus system up to 115 kbaud
RS485 bus cable and adaptor 7XV5103-□AA□□;
see part 14.

Connection diagram

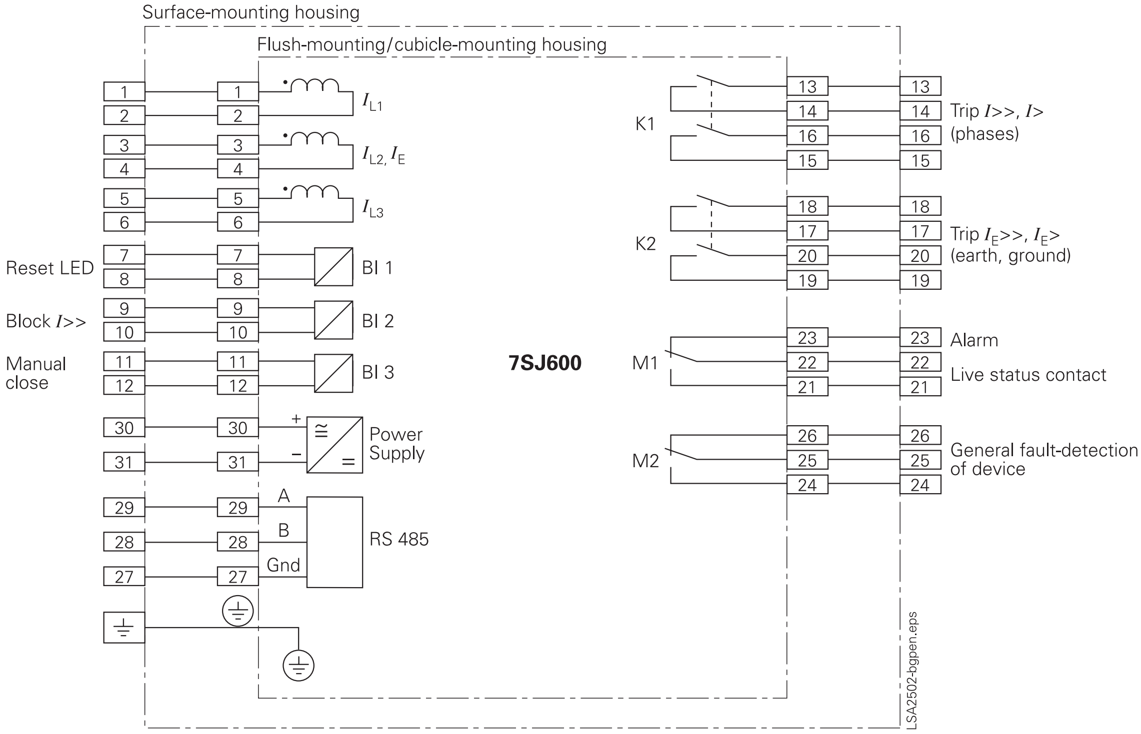


Fig. 5/32
Connection diagram according to IEC standard

SIPROTEC 7SJ602
Multifunction Overcurrent and Motor Protection Relay

Fig. 5/33 SIPROTEC 7SJ602 multifunction protection relay

Description

The SIPROTEC 7SJ602 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for line, transformer and generator differential protection. The SIPROTEC 7SJ602 provides definite-time and inverse-time overcurrent protection along with overload and unbalanced-load (negative-sequence) protection for a very comprehensive relay package.

For applications with earth-current detection two versions are available: One version with four current transformer inputs for non-directional earth (ground) fault detection and a second version with three current inputs (2 phase, 1 earth/ground) and one voltage input for directional earth (ground) fault detection.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Feeder protection

- Overcurrent-time protection
- Sensitive earth-fault detection
- Directional sensitive earth-fault detection
- Displacement voltage
- Disk emulation
- Overload protection
- Breaker failure protection
- Negative-sequence protection
- Cold load pickup
- Auto-reclosure
- Trip circuit supervision

Motor protection

- Starting time supervision
- Locked rotor
- Restart inhibit
- Undercurrent monitoring
- Temperature monitoring

Control functions

- Commands for control of a circuit-breaker
- Control via keyboard, , DIGSI 4 or SCADA system

Measuring functions

- Operational measured values I, V
- Power measurement P, Q, S, W_p, W_q
- Slavepointer
- Mean values

Monitoring functions

- Fault event logging with time stamp (buffered)
- 8 oscillographic fault records
- Continuous self-monitoring

Communication interfaces

- System interface
  – IEC 60870-5-103 protocol
  – PROFIBUS-DP
  – MODBUS RTU/ASCII
- Front interface for DIGSI 4

Hardware

- 4 current transformers or
- 3 current + 1 voltage transformers
- 3 binary inputs
- 4 output relays
- 1 live status contact

5

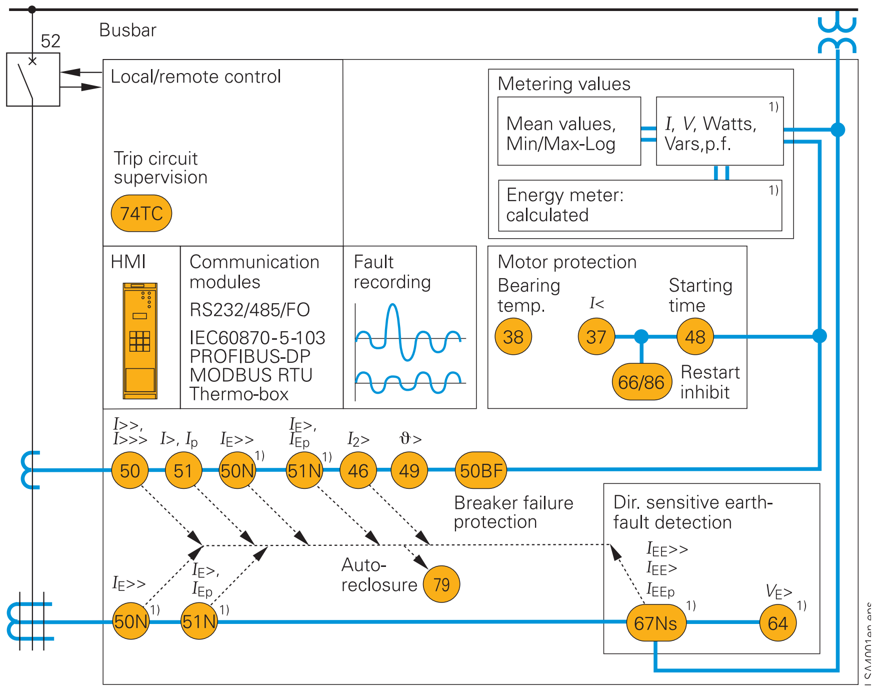
Application

Wide range of applications

The SIPROTEC 7SJ602 is a numerical overcurrent relay which, in addition to its primary use in radial distribution networks and motor protection, can also be employed as backup for feeder, transformer and generator differential protection.

The SIPROTEC 7SJ602 provides definite-time and inverse-time overcurrent protection along with overload and negative sequence protection for a very comprehensive relay package. In this way, equipment such as motors can be protected against asymmetric and excessive loading. Asymmetric short-circuits with currents that can be smaller than the largest possible load currents or phase interruptions are reliably detected.

The integrated control function allows simple control of a circuit-breaker or disconnector (electrically operated/motorized switch) via the integrated HMI, DIGSI or SCADA.



1) alternatively; see "Selection and ordering data" for details

Fig. 5/34 Function diagram

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I>>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
64	$V_E>$	Displacement voltage
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device, e.g. bearing temperature monitoring
74TC		Trip circuit supervision breaker control

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485, RS232, fiber-optic)
- Power supply.

The rated CT currents applied to the SIPROTEC 7SJ602 can be 1 A or 5 A. This is selectable via a jumper inside the relay.

Two different housings are available. The flush-mounting version has terminals accessible from the rear. The surface-mounting version has terminals accessible from the front. Retrofitting of a communication module, or replacement of an existing communication module with a new one are both possible.

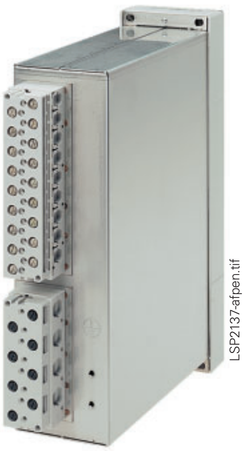


Fig. 5/35
Rear view of flush-mounting housing

Fig. 5/36
View from below showing system interface (SCADA) with FO connection (for remote communications)

Protection functions

Definite-time characteristics

The definite-time overcurrent function is based on phase-selective evaluation of the three phase currents and earth current.

The definite-time overcurrent protection for the 3 phase currents has a low-set overcurrent element ($I>$), a high-set overcurrent element ($I>>$) and a high-set instantaneous element ($I>>>$). Intentional trip delays can be set from 0 to 60 seconds for the low-set and high-set overcurrent elements.

The instantaneous zone $I>>>$ trips without any intentional delay. The definite-time overcurrent protection for the earth (ground) current has a low-set overcurrent element ($I_E>$) and a high-set overcurrent element ($I_E>>$). Intentional trip delays can be parameterized from 0 to 60 seconds.

Inverse-time characteristics

In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared.

This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

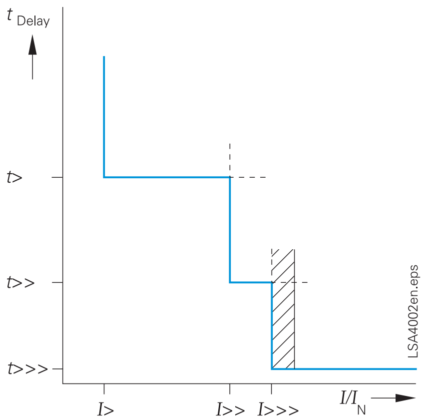


Fig. 5/37
Definite-time overcurrent characteristic

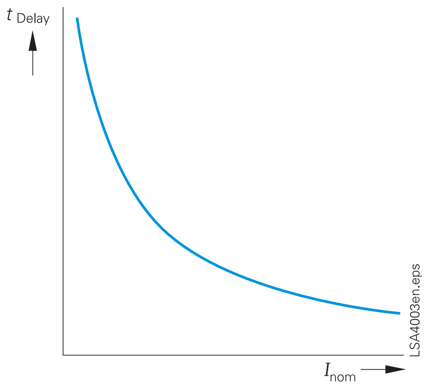


Fig. 5/38
Inverse-time overcurrent characteristic

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	
I squared *T*	•	
RI/RD-type		

Protection functions

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns)

The direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0. For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees (cosine/sinus).

Two modes of earth-fault direction detection can be implemented: tripping or in "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one inverse characteristic.
- Each element can be set in forward, reverse, or non-directional.

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

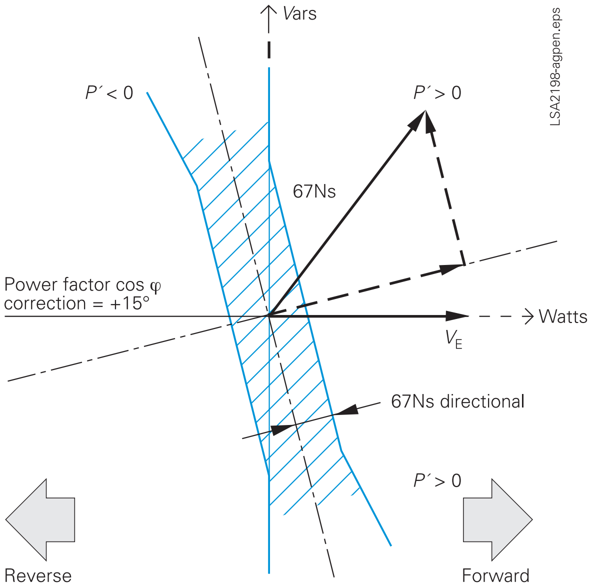


Fig. 5/39 Directional determination using cosine measurements

Thermal overload protection (ANSI 49)

The thermal overload protection function provides tripping or alarming based on a thermal model calculated from phase currents.

The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (also called thermo-box). If there is no thermo-box it is assumed that the ambient temperatures are constant.

Thermal overload protection without preload:

For thermal overload protection without consideration of the preload current, the following tripping characteristic applies only when

$I \geq 1.1 \cdot I_L$

For different thermal time constants T_L, the tripping time t is calculated in accordance with the following equation:

$$t = \frac{35}{\left(\frac{I}{I_L}\right)^2 - 1} \cdot T_L$$

I = Load current
I_L = Pickup current
T_L = Time multiplier

The reset threshold is above $1.03125 \cdot I/I_N$

Thermal overload protection with preload

The thermal overload protection with consideration of preload current constantly updates the thermal model calculation regardless of the magnitude of the phase currents. The tripping time t is calculated in accordance with the following tripping characteristic (complete memory in accordance with IEC 60255-8).

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

t = Tripping time after beginning of the thermal overload
τ = $35.5 \cdot T_L$
I_{pre} = Preload current
I = Load current
k = k factor (in accordance with IEC 60255-8)
ln = Natural logarithm
T_L = Time multiplier
I_N = Rated (nominal) current

Protection functions

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if after a trip command, current is still flowing in the faulted circuit. As an option it is possible to make use of the circuit-breaker position indication.

Negative-sequence protection (I_2>>, I_2>/ANSI 46 Unbalanced-load protection)

The negative-sequence protection (see Fig. 5/40) detects a phase failure or load unbalance due to network asymmetry. Interruptions, short-circuits or crossed connections to the current transformers are detected.

Furthermore, low level single-phase and two-phase short-circuits (such as faults beyond a transformer) as well as phase interruptions can be detected.

This function is especially useful for motors since negative-sequence currents cause impermissible overheating of the rotor.

In order to detect the unbalanced load, the ratio of negative phase-sequence current to rated current is evaluated.

I_2 = negative-sequence current
T_{12} = tripping time

Transformer protection

The high-set element permits current coordination where the overcurrent element functions as a backup for the lower-level protection relays, and the overload function protects the transformer from thermal overload. Low-current single-phase faults on the low voltage side that result in negative phase-sequence current on the high-voltage side can be detected with the negative-sequence protection.

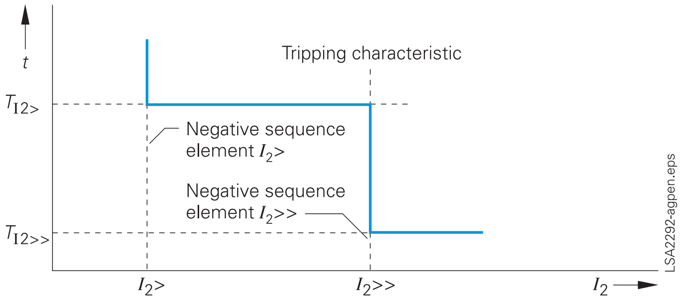


Fig. 5/40 Tripping characteristics of the negative-sequence protection function

Cold load pickup

By means of a binary input which can be wired from a manual close contact, it is possible to switch the overcurrent pickup settings to less sensitive settings for a programmable duration of time. After the set time has expired, the pickup settings automatically return to their original setting. This can compensate for initial inrush when energizing a circuit without compromising the sensitivity of the overcurrent elements during steady state conditions.

3-pole multishot auto-reclosure (AR, ANSI 79)

Auto-reclosure (AR) enables 3-phase auto-reclosing of a feeder which has previously been disconnected by time-overcurrent protection.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for trip circuit monitoring.

Control

The relay permits circuit-breakers to be opened and closed without command feedback. The circuit-breaker/disconnector may be controlled by DIGSI, or by the integrated HMI, or by the LSA/SCADA equipment connected to the interface.

Protection functions

Switch-onto-fault protection

If switched onto a fault, instantaneous tripping can be effected. If the internal control function is used (local or via serial interface), the manual closing function is available without any additional wiring. If the control switch is connected to a circuit-breaker by-passing the internal control function, manual detection using a binary input is implemented.

Busbar protection (Reverse interlocking)

Binary inputs can be used to block any of the six current stages. Parameters are assigned to decide whether the input circuit is to operate in open-circuit or closed-circuit mode. In this case, reverse interlocking provides high-speed busbar protection in radial or ring power systems that are opened at one point. The reverse interlocking principle is used, for example, in medium-voltage power systems and in switchgear for power plants, where a high-voltage system transformer feeds a busbar section with several medium-voltage outgoing feeders.

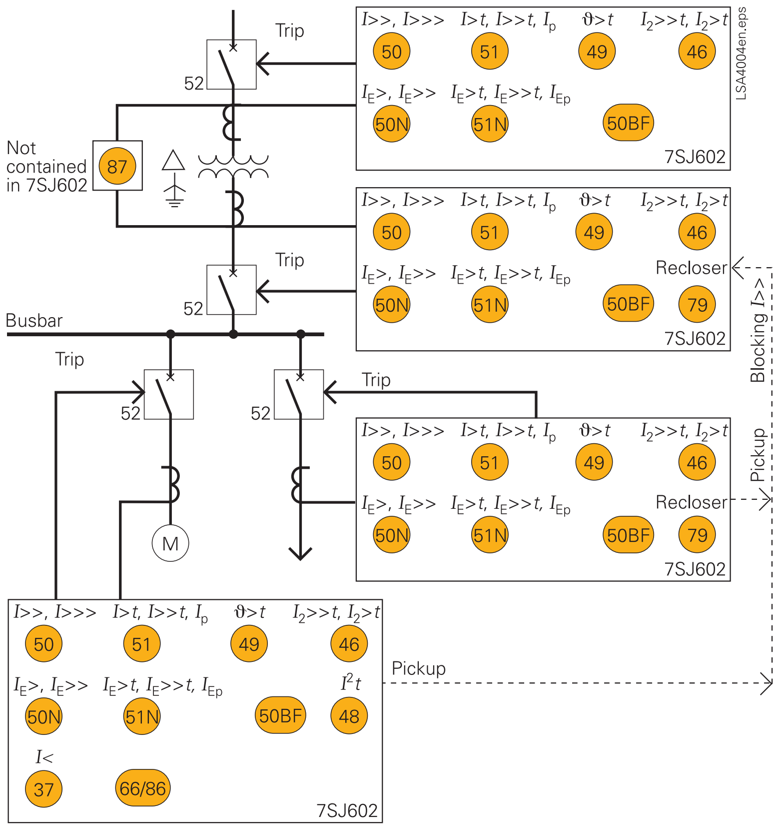


Fig. 5/41 Reserve interlocking

5

Motor protection

Starting time supervision (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups that might occur when excessive load torque occurs, excessive voltage drops occur within the motor or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

$$t_{TRIP} = \left(\frac{I_{start}}{I_{rms}}\right)^2 \cdot t_{start\ max}$$

for $I_{rms} > I_{start}$, reset ratio $\frac{I_N}{I_{start}}$ approx. 0.94

t_{TRIP} = tripping time
I_{start} = start-up current of the motor
$t_{start\ max}$ = maximum permissible starting time
I_{rms} = actual current flowing

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current and the temperature characteristic is shown in a schematic diagram. The reclosing lockout only permits startup of the motor if the rotor has sufficient thermal reserves for a complete start-up.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which may occur due to a reduced motor load, is detected. This can cause shaft breakage, no-load operation of pumps or fan failure.

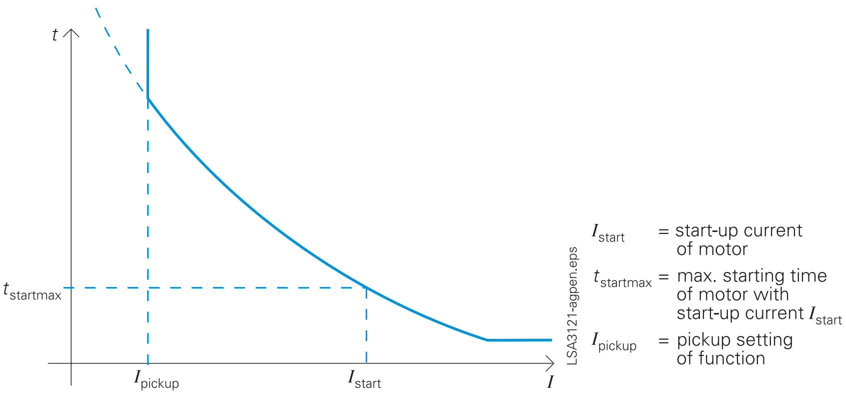


Fig. 5/42 Starting time supervision

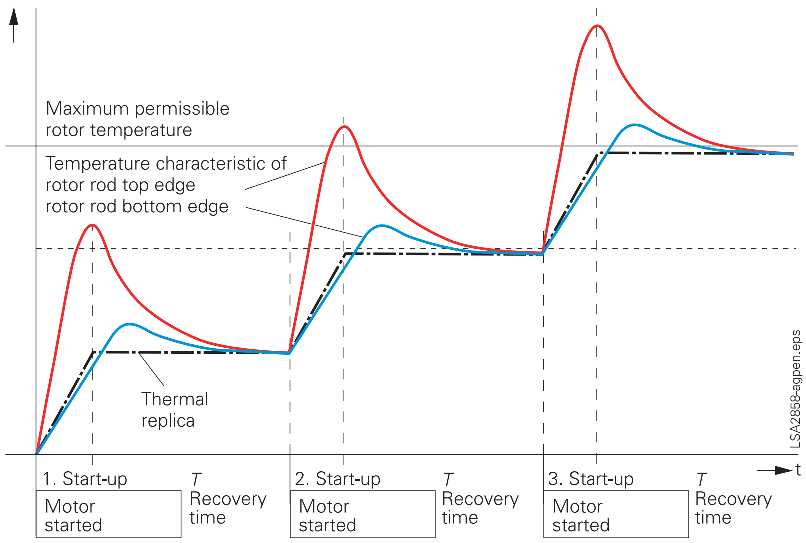


Fig. 5/43 Restart inhibit

Temperature monitoring (ANSI 38)

A temperature monitoring box with a total of 6 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via a temperature monitoring box (also called thermo-box or RTD-box) (see "Accessories").

Additional functions

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_E (67N_S) if existing
- Power Watts, Vars, VA/P, Q, S
- Power factor (cos φ),
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current, voltage and power values

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability.

Local PC interface

The SIPROTEC 7SJ602 is fitted with an RS232 PC front port. A PC can be connected to ease set-up of the relay using the Windows-based program DIGSI which runs under MS-Windows. It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and 1 event log containing up to 30 events.

System interface on bottom of the unit

A communication module located on the bottom part of the unit incorporates optional equipment complements and readily permits retrofitting. It guarantees the ability to comply with the requirements of different communication interfaces.

This interface is used to carry out communication with a control or a protection system and supports a variety of communication protocols and interface designs, depending on the module connected.

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area.
IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

MODBUS RTU

MODBUS RTU is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

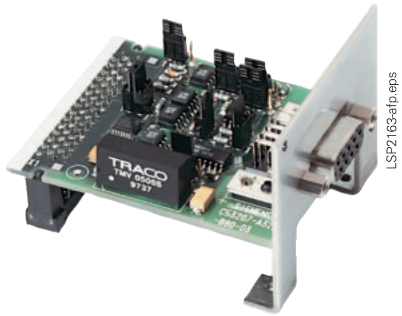


Fig. 5/44
Electrical communication module

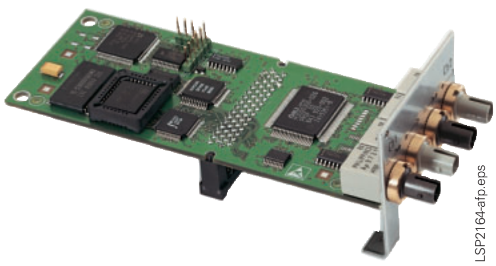


Fig. 5/45
Fiber-optic double ring communication module

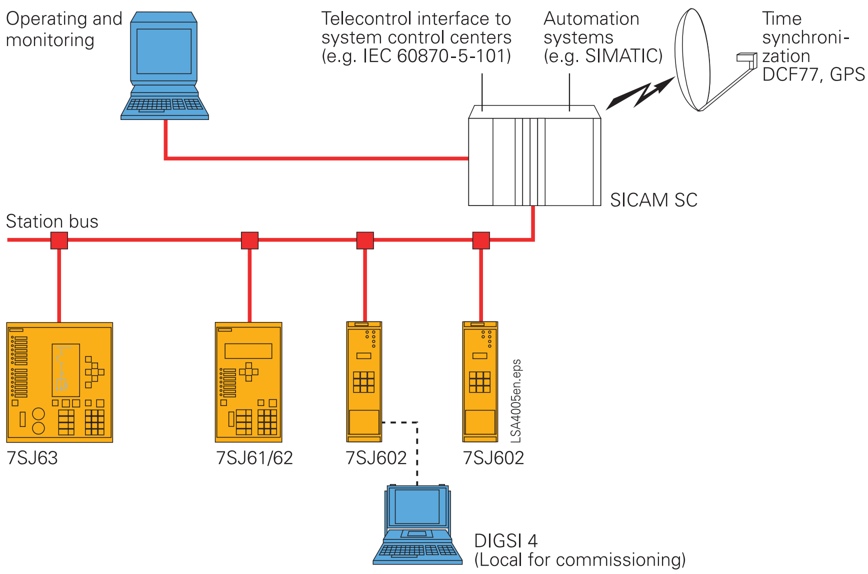


Fig. 5/46 System solution/communication

Typical connections

CT connections

Fig. 5/47 Standard
- Phase current measured
- Earth current measured (e. g. core balance CT)

Fig. 5/48 Standard connection
- Connection of 3 CTs with residual connection for neutral fault

Fig. 5/49
- Isolated networks only

7SJ6021/7SJ6025

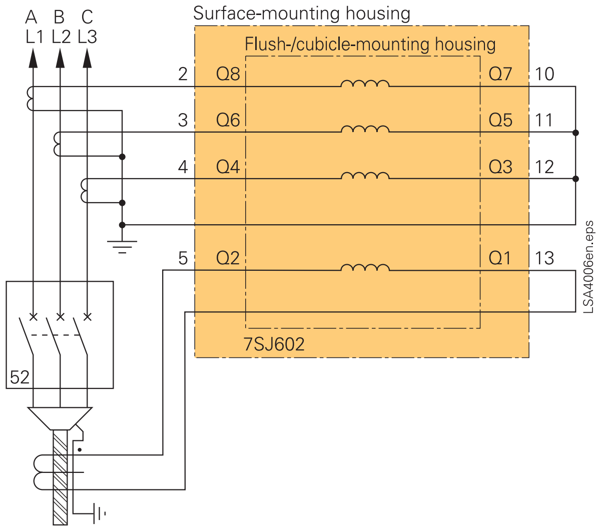


Fig. 5/47
Connection of 4 CTs with measurement of the earth (ground) current

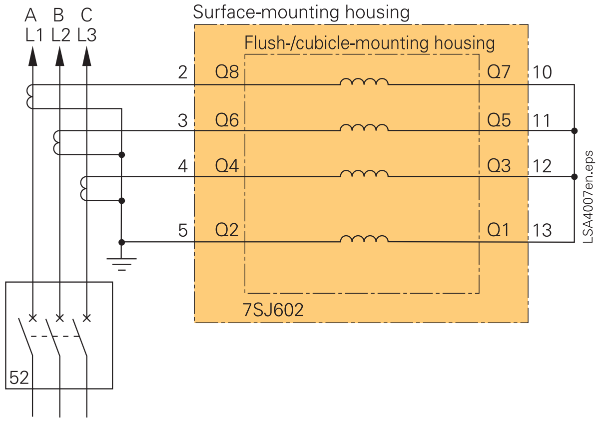


Fig. 5/48
Connection of 3 CTs with residual connection for neutral fault

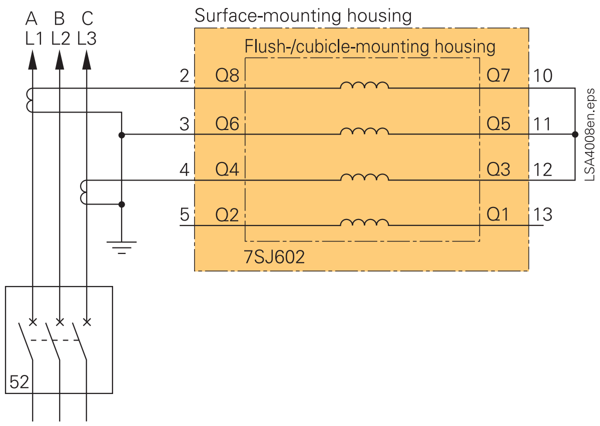


Fig. 5/49
Connection of 2 CTs only for isolated or resonant-earthed (grounded) power systems

Typical connections

7SJ6022/7SJ6026

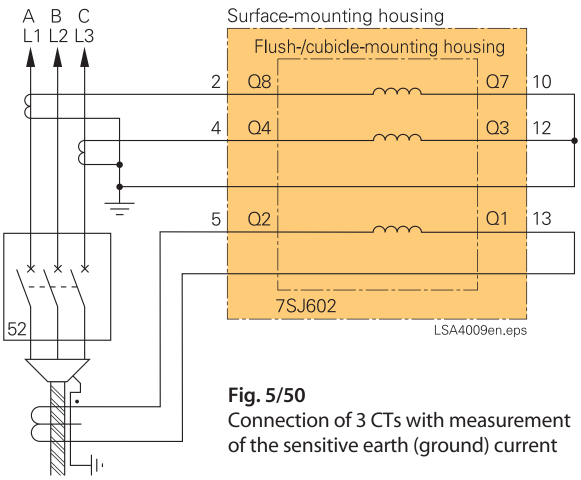


Fig. 5/50
Connection of 3 CTs with measurement of the sensitive earth (ground) current

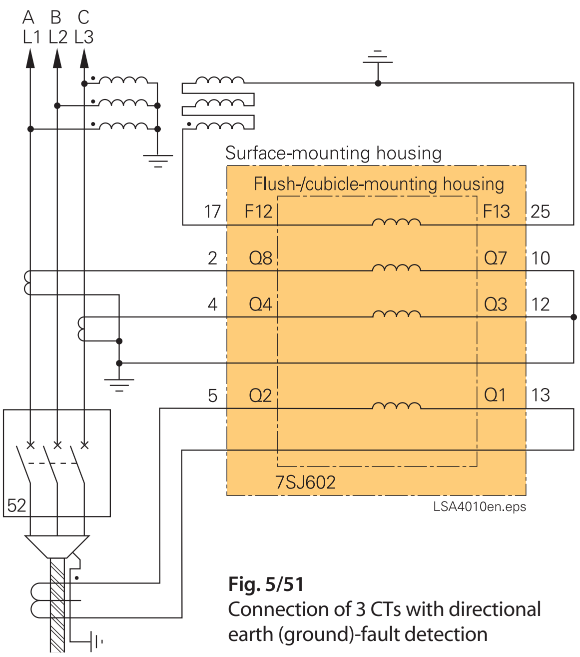


Fig. 5/51
Connection of 3 CTs with directional earth (ground)-fault detection

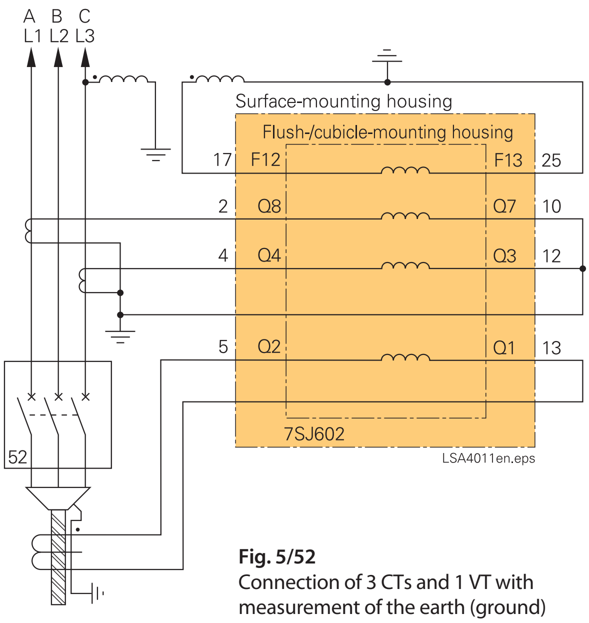


Fig. 5/52
Connection of 3 CTs and 1 VT with measurement of the earth (ground) current and one phase voltage

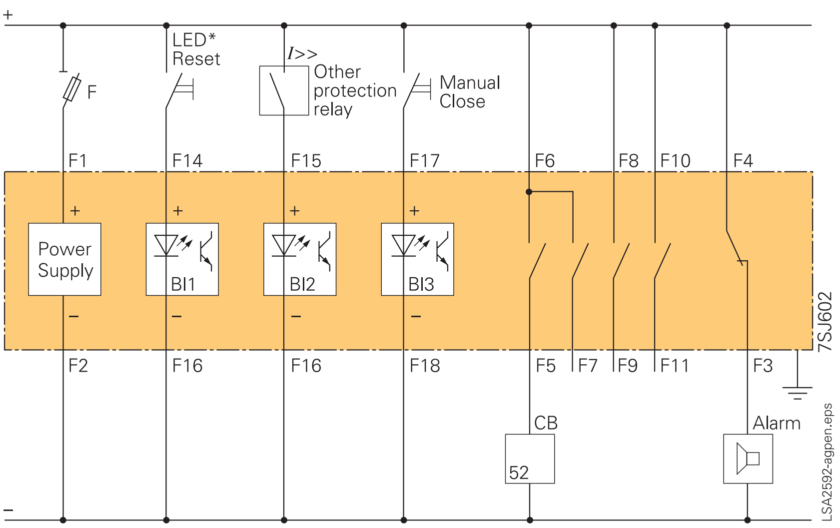


Fig. 5/53 Example of typical wiring

Technical data

General unit data	
CT circuits	
Rated current I_N	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A or < 8 A (settable)
Rated frequency f_N	50/60 Hz (selectable)
Power consumption	
Current input at I_N = 1 A	< 0.1 VA
at I_N = 5 A	< 0.3 VA
For sensitive earth-fault detection at 1 A	Approx. 0.05 VA
Overload capability	
Thermal (r.m.s)	100 x I_N for 1 s 30 x I_N for 10 s 4 x I_N continuous
Dynamic (pulse current)	250 x I_N one half cycle
Overload capability if equipped with sensitive earth-fault current transformer	
Thermal (r.m.s.)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)
Voltage transformer	
Rated voltage V_N	100 to 125 V
Power consumption at V_N = 100 V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage)	
Thermal (r.m.s.)	230 V continuous
Power supply	
Power supply via integrated DC/DC converter	
Rated auxiliary voltage V_{aux} / permissible variations	24/48 V DC/± 20 % 60/110 V DC/± 20 % 110/125/220/250 V DC/± 20 % 115 V AC/- 20 %, + 15 % 230 V AC/- 20 %, + 15 %
Superimposed AC voltage, peak-to-peak	
At rated voltage	≤ 12 %
At limits of admissible voltage	≤ 6 %
Power consumption	Approx. 3 to 6 W, depending on operational status and selected auxiliary voltage
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms at V_{aux} ≥ 110 V AC/DC ≥ 20 ms at V_{aux} ≥ 24 V DC
Binary outputs	
Trip relays	4 (configurable)
Contacts per relay	1 NO/form A (Two contacts changeable to NC/form B, via jumpers)
Switching capacity	
Make	1000 W/VA
Break	30 VA, 40 W resistive 25 VA with L/R ≤ 50 ms
Switching voltage	250 V
Permissible current	
Continuous	5 A
For 0.5 s	30 A
Permissible total current	
For common potential:	
Continuous	5 A
For 0.5 s	30 A

Alarm relays	1
Contacts per relay	1 NO/NC (form A/B)
Switching capacity	
Make	1000 W/VA
Break	30 VA, 40 W resistive 25 VA with L/R ≤ 50 ms
Switching voltage	250 V
Permissible current	5 A continuous
Binary inputs	
Number	3 (configurable)
Operating voltage	24 to 250 V DC
Current consumption, independent of operating voltage	Approx. 1.8 mA
Pickup threshold, selectable via bridges	
Rated aux. voltage	
24/48/60/110 V DC V_{pickup}	≥ 19 V DC
110/125/220/250 V DC V_{pickup}	≥ 88 V DC
Permissible maximum voltage	300 V DC
***Connection** (with screws)*	
Current terminals	
Connection ring cable lugs	W_{max} = 11 mm, d_1 = 5 mm
Wire size	2.0 - 5.3 mm^2 (AWG 14-10)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	2.0 - 5.3 mm^2 (AWG 14-10)
Voltage terminals	
Connection ring cable lugs	W_{max} = 10 mm, d_1 = 4 mm
Wire size	0.5 - 3.3 mm^2 (AWG 20-12)
Direct connection	Solid conductor, flexible lead, connector sleeve
Wire size	0.5 - 3.3 mm^2 (AWG 20-12)
Unit design	
Housing 7XP20	For dimensions please refer to dimension drawings
Degree of protection acc. to EN 60529	
For the device	
in surface-mounting housing	IP 51
in flush-mounting housing	
front	IP 51
rear	IP 20
For personal safety	IP 2x with closed protection cover
Weight	
Flush mounting/ cubicle mounting	Approx. 4 kg
Surface mounting	Approx. 4.5 kg

Serial interfaces	
Operating interface	
Connection	At front side, non-isolated, RS232, 9-pin subminiature connector
Operation	With DIGSI 4.3 or higher
Transmission speed	As delivered 19200 baud, parity: 8E1 Min. 1200 baud Max. 19200 baud
Distance	15 m

5

Technical data

System interface (bottom of unit)	
IEC 60870-5-103 protocol	
Connection	Isolated interface for data transmission
Transmission rate	Min. 1200 baud, max. 19200 baud As delivered 9600 baud
RS232/RS485 acc. to ordered version	
Connection	9-pin subminiature connector on the bottom part of the housing
Test voltage	500 V AC
RS232 maximum distance	15 m
RS485 maximum distance	1000 m
Fiber-optic	
Connector type	ST connector on the bottom part of the housing
Optical wavelength	λ = 820 nm
Laser class 1 acc. to EN 60825-1/-2	For glass fiber 50/125 µm or 62.5/125 µm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Bridgeable distance	Max. 1.5 km
No character position	Selectable, setting as supplied „light off"
PROFIBUS-DP	
Isolated interface for data transfer to a control center	
Transmission rate	Up to 1.5 Mbaud
Transmission reliability	Hamming distance d = 4
RS485	
Connection	9-pin subminiature connector
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
Optical wavelength	λ = 820 nm
Laser class 1 acc. to EN 60825-1-2	For glass fiber 50/125 µm or 62.5/125 µm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
Idle state of interface	Settable, setting as supplied "light off"

System interface (bottom of unit), cont'd	
MODBUS RTU / ASCII	
Isolated interface for data transfer to a control center	
Transmission rate	Up to 19200 baud
Transmission reliability	Hamming distance d = 4
RS485	
Connection	9-pin subminiature connector
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
Optical wavelength	820 nm
Laser class 1 acc. to EN 60825-1-2	For glass fiber 50/125 µm or 62.5/125 µm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
Idle state of interface	"Light off"

Electrical tests	
Specifications	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Insulation tests	
High-voltage tests (routine test) all circuits except for auxiliary voltage, binary inputs and communication interfaces	2.5 kV (r.m.s. value), 50 Hz
High-voltage tests (routine test) Auxiliary voltage and binary inputs	3.5 kV DC
High-voltage tests (routine test) only isolated communication interfaces	500 V (r.m.s. value); 50 Hz
Impulse voltage tests (type test) all circuits, except communication interfaces	5 kV (peak value), 1.2/50 µs, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for interference immunity; *type tests*	
Standards	IEC 60255-6; IEC 60255-22, (product standard) EN 50082-2 (generic standard) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz, τ = 15 µs; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge, 15 kV air gap discharge, both polarities, 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report), class III	10 V/m, 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, AM 80 %; 1 kHz duration > 10 s
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m, 900 MHz, repetition frequency 200 Hz duty cycle 50 % PM

Technical data

EMC tests for interference immunity; type tests, (cont'd)	
Fast transients interference/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
Surge voltage IEC 61000-4-5, class III Auxiliary voltage	Pulse: 1.2/50 μs From circuit to circuit (common mode): 2 kV, 12 Ω, 9 μF; Across contacts (diff. mode): 1 kV, 2 Ω, 18 μF
Measuring inputs, binary inputs/outputs	From circuit to circuit (common mode): 2 kV, 42 Ω, 0.5 μF; Across contacts (diff. mode): 1 kV, 42 Ω, 0.5 μF
Conducted RF amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m continuous 300 A/m for 3 s, 50 Hz 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s R_i = 150 to 200 Ω;
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV, 10/150 ns, 50 surges per s, both polarities; duration 2 s, R_i = 80 Ω;
Radiated electromagnetic interference ANSI/IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694/ IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω;

EMC tests interference emission; type tests	
Standard	EN 50081-* (generic specification)
Conducted interferences, only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz limit class B
Radio interference field strength IEC/CISPR 22	30 to 1000 MHz limit class B
Harmonic currents on incoming lines of system at 230 V AC IEC 61000-3-2	Unit belongs to class D (applies only to units with > 50 VA power consumption)
Voltage fluctuation and flicker range on incoming lines of system at 230 V AC IEC 61000-3-3	Limit values are adhered to

Mechanical stress tests	
Vibration, shock and seismic vibration	
During operation	
Standards	Acc. to IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude; 60 to 150 Hz: 0.5 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine, acceleration 5 *g*, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transportation	
Standards	Acc. to IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sine, acceleration 15 *g*, duration 11 ms; 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine, acceleration 10 *g*, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests	
Temperatures	
Recommended temperature During operation	–5 °C to +55 °C /23 °F to 131 °F, (> 55 °C decreased display contrast)
Limit temperature During operation During storage During transport (Storage and transport with standard works packaging)	–20 °C to +70 °C /–4 °F to 158 °F –25 °C to +55 °C /–13 °F to 131 °F –25 °C to +70 °C /–13 °F to 158 °F
Humidity	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average: ≤ 75 % relative humidity, on 56 days per year 95 % relative humidity, condensation not permissible!

Technical data

Functions	
***Definite-time overcurrent protection** (ANSI 50, 50N)*	
Setting ranges/steps	
Low-set overcurrent element	
Phase $I>$	I/I_N = 0.1 to 25 (steps 0.1); or ∞
Earth $I_E>$	I/I_N = 0.05 to 25 (steps 0.01); or ∞
High-set overcurrent element	
Phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1); or ∞
Earth $I_E>>$	I/I_N = 0.05 to 25 (steps 0.01); or ∞
Instantaneous tripping	
Phase $I>>>$	I/I_N = 0.3 to 12.5 (steps 0.1); or ∞
Delay times T for $I>$, $I_E>$, $I>>$ and $I_E>>$ The set times are pure delay times	0 to 60 s (steps 0.01 s)
Pickup times $I>$, $I>>$, $I_E>$, $I_E>>$	
At 2 x setting value, without meas. repetition	Approx. 25 ms
At 2 x setting value, with meas. repetition	Approx. 35 ms
Pickup times for $I>>>$ at 2 x setting value	Approx. 15 ms
Reset times $I>$, $I>>$, $I_E>$, $I_E>>$	Approx. 40 ms
Reset time $I>>>$	Approx. 50 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 55 ms
Tolerances	
Pickup values $I>$, $I>>$, $I>>>$, $I_E>$, $I_E>>$	5 % of setting value or 5 % of rated value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\,°C \leq \Theta_{amb} \leq 40\,°C$ / $23\,°F \leq \Theta_{amb} \leq 104\,°F$	≤ 0.5 %/10 K
Frequency, range	
$0.98 \leq f/f_N \leq 1.02$	≤ 1.5 %
$0.95 \leq f/f_N \leq 1.05$	≤ 2.5 %
Harmonics	
Up to 10 % of 3rd harmonic	≤ 1%
Up to 10 % of 5th harmonic	≤ 1 %

***Inverse-time overcurrent protection** (ANSI 51/51N)*	
Setting ranges/steps	
Low-set overcurrent element	
Phase I_p	I/I_N = 0.1 to 4 (steps 0.1)
Earth I_{Ep}	I/I_N = 0.05 to 4 (steps 0.01)
Time multiplier for I_p, I_{Ep} (IEC charac.)	T_p = 0.05 to 3.2 s (steps 0.01 s)
Time multiplier for I_p, I_{Ep} (ANSI charac.)	D = 0.5 to 15 s (steps 0.1 s)
High-set overcurrent element	
Phase $I>>$	I/I_N = 0.1 to 25 (steps 0.1); or ∞
Earth $I_E>>$	I/I_N = 0.05 to 25 (steps 0.01); or ∞
Instantaneous tripping	
Phase $I>>>$	I/I_N = 0.3 to 12.5 (steps 0.1); or ∞
Delay time $T_{I}>>$	0 to 60 s (steps 0.01 s)
Tripping time characteristic acc. to IEC	See page 5/33
Pickup threshold	Approx. 1.1 x I_p
Reset threshold, alternatively disk emulation	Approx. 1.03 x I_p
Dropout time	
50 Hz	Approx. 50 ms
60 HZ	Approx. 60 ms
Tolerances	
Pickup values	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_p \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\,°C \leq \Theta_{amb} \leq 40\,°C$ / $-23\,°F \leq \Theta_{amb} \leq 104\,°F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value
Tripping characteristic acc. to ANSI/IEEE	See page 5/33
Pickup threshold	Approx. 1.06 x I_p
Dropout threshold, alternatively disk emulation	Approx. 1.03 x I_p
Tolerances	
Pickup threshold	5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_p \leq 20$ and $0.5 \leq I/I_p \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\,°C \leq \Theta_{amb} \leq 40\,°C$ / $23\,°F \leq \Theta_{amb} \leq 104\,°F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value

Technical data

(Sensitive) earth-fault protection (directional/non-directional)	
Definite-time earth-fault protection *(ANSI 50Ns)*	
Setting ranges/steps	
Low-set element $I_{EE}>$	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
High-set element $I_{EE}>>$	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
Delay times T for $I_{EE}>$ and $I_{EE}>>$	0 to 60 s (steps 0.01 s)
Pickup times $I_{EE}>$, $I_{EE}>>$	
At 2 x setting value without meas. repetition	Approx. 35 ms
At 2 x setting value with meas. repetition	Approx. 55 ms
Reset times $I_{EE}>$, $I_{EE}>>$ At 50 Hz At 60 Hz	 Approx. 65 ms Approx. 95 ms
Reset ratios	Approx. 0.95
Overshot time	Approx. 55 ms
Tolerances	
Pickup values $I_{EE}>$, $I_{EE}>>$	5 % of setting value or 5 % of rated value
Delay times T	1 % of setting value or 10 ms
Influencing variables	
Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, ranges: $0.98 \leq f/f_N \leq 1.02$ $0.95 \leq f/f_N \leq 1.05$	 ≤ 1.5 % ≤ 2.5 %
Harmonics Up to 10 % of 3rd harmonic Up to 10 % of 5rd harmonic	 ≤ 1% ≤ 1 %
Inverse-time earth-fault protection *(ANSI 51Ns)*	
Setting ranges/steps	
Low-set element I_{EEp}	I/I_{EEN} = 0.003 to 1.4 (steps 0.001)
Time multiplier for I_{EEp} (IEC characteristic)	T_p = 0.05 to 3.2 s (steps 0.01 s)
Time multiplier for I_{EEp} (ANSI characteristic)	D = 0.5 to 15 s (steps 0.1 s)
High-set element $I_{EE}>>$	I/I_{EEN} = 0.003 to 1.5 (steps 0.001); or ∞ (deactivated)
Delay time T for $I_{EE}>>$	0 to 60 s (steps 0.01 s)
Tripping time characteristic acc. to IEC	See page 5/33
Pickup threshold	Approx. 1.1 x I_{EEp}
Reset threshold alternatively disk emulation	Approx. 1.03 x I_{EEp}
Dropout time 50 Hz 60 Hz	 Approx. 50 ms Approx. 60 ms
Tolerances Pickup values	 5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_{EEp} \leq 20$ and $0.5 \leq I/I_{EEN} \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %

Inverse-time earth-fault protection *(ANSI 51Ns), cont'd*	
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value
Tripping characteristic acc. to ANSI/IEEE	See page 5/33
Pickup threshold	Approx. 1.06 x I_{EEp}
Dropout threshold, alternatively disk emulation	Approx. 1.03 x I_{EEp}
Tolerances Pickup threshold	 5 % of setting value or 5 % of rated value
Timing period for $2 \leq I/I_{EEp} \leq 20$ and $0.5 \leq I/I_{EEN} \leq 24$	5 % of theoretical value ± 2 % current tolerance; at least 30 ms
Influencing variables Auxiliary voltage, range: $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range: $-5\ °C \leq \Theta_{amb} \leq 40\ °C$ / $23\ °F \leq \Theta_{amb} \leq 104\ °F$	≤ 0.5 %/10 K
Frequency, range: $0.95 \leq f/f_N \leq 1.05$	≤ 8 %, referred to theoretical time value
Direction detection *(ANSI 67Ns)*	
Direction measurement	I_E, V_E (measured)
Measuring principle	Active/reactive measurement
Measuring enable For sensitive input	 I/I_{EEN} = 0.003 to 1.2 (in steps of 0.001 I/I_{EEN})
Reset ratio	Approx. 0.8
Measuring method	cos φ and sin φ
Direction vector	-45 ° to +45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ Delay}$	1 to 60 s (steps 1 s)
Angle correction for cable converter (for resonant-earthed system)	In 2 operating points F1 and F2
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current values I_1, I_2 For sensitive input	 I/I_{EEN} = 0.003 to 1.6 (in steps of 0.001 I/I_{EEN})
Measuring tolerance acc. to DIN 57435	2 % of the setting value or 1 mA
Angle tolerance	3 °
Displacement voltage (ANSI 64)	
Displacement voltage, measured	$V_E>/V_N$ = 0.02 to 1.3 (steps 0.001)
Measuring time	Approx. 60 ms
Pickup delay time	0.04 to 320 s or ∞ (steps 0.01 s)
Time delay	0.1 to 40000 s or ∞ (steps 0.01 s)
Dropout ratio	0.95 or (pickup value -0.6 V)
Measuring tolerance V_E (measured)	 3 % of setting value, or 0.3 V
Operating time tolerances	1 % of setting value, or 10 ms
The set times are pure delay times	

Technical data

Thermal overload protection with memory *(ANSI 49) with preload*	
Setting ranges	
Factor k according to IEC 60255-8	0.40 to 2 (steps 0.01)
Thermal time constant τ_{th}	1 to 999.9 min (steps 0.1 min)
Thermal warning stage $\Theta_{alarm}/\Theta_{trip}$	50 to 99 % referred to trip temperature rise (steps 1 %)
Prolongation factor at motor stand-still k_τ	1 to 10 (steps 0.01)
Reset ratios	
Θ/Θ_{trip} Θ/Θ_{alarm}	Reset below 0.99 Θ_{alarm} Approx. 0.99
Tolerances	
Referring to k · I_N	± 5 % (class 5 % acc. to IEC 60255-8)
Referring to trip time	± 5 % ± 2 s (class 5 % acc. to IEC 60255-8)
Influencing variables	
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range - 5 °C ≤ Θ_{amb} ≤ + 40 °C / 23 °F ≤ Θ_{amb} ≤ 104 °F	≤ 0.5 %/10 K
Frequency, range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %

Thermal overload protection without memory *(ANSI 49) without preload*	
Setting ranges	
Pickup value	I_L/I_N = 0.4 to 4 (steps 0.1)
Time multiplier t_L (= t_6 -time)	1 to 120 s (steps 0.1 s)
Reset ratio I/I_L	Approx. 0.94
Tolerances	
Referring to pickup threshold 1.1 I_L	± 5 % of setting value or 5 % of rated value
Referring to trip time	± 5 % ± 2 s
Influencing variables	
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %
Temperature, range - 5 °C ≤ Θ_{amb} ≤ + 40 °C / 23 °F ≤ Θ_{amb} ≤ 104 °F	≤ 0.5 %/10 K
Frequency, range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %

Breaker failure protection	
Setting ranges/steps	
Pickup of current element	CB $I>/I_N$ = 0.04 to 1.0 (steps 0.01)
Delay time	0.06 to 60 s or ∞ (steps 0.01 s)
Pickup times (with internal start) (via control) (with external start)	is contained in the delay time is contained in the delay time is contained in the delay time
Dropout time	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value
Delay time	1 % or 20 ms

Negative-sequence protection *(ANSI 46)*		
Setting ranges/steps		
Tripping stages I_2> and I_2>>	8 to 80 % to I_N (steps 1 %)	
Delay times T (I_2>), T (I_2>>)	0 to 60 s (steps 0.01 s)	
Lower function limit	At least one phase current ≥ 0.1 x I_N	
Pickup times	at f_N = 50 Hz	at f_N = 60 Hz
Tripping stages I_2> and I_2>>	Approx. 60 ms	Approx. 75 ms
But with currents I/I_N > 1.5 (overcurrent case) or negative-sequence current < (set value +0.1 x I_N)	Approx. 200 ms	Approx. 310 ms
Reset times		
Tripping stages I_2> and I_2>>	Approx. 35 ms	Approx. 42 ms
Reset ratios		
Tripping stages I_2> and I_2>>	Approx. 0.9 to 0.01 x I_N	
Tolerances		
Pickup values I_2>, I_2>>		
Current $I/I_N \leq 1.5$ Current I/I_N > 1.5	± 1 % of I_N ± 5 % of set value ± 5 % of I_N ± 5 % of set value	
Delay times T (I_2>) and T (I_2>>)	± 1 % but min. 10 ms	
Influencing variables		
Auxiliary DC voltage, range $0.8 \leq V_{aux}/V_{auxN} \leq 1.2$	≤ 1 %	
Temperature, range –5 °C ≤ Θ_{amb} +40 °C / 23 °F ≤ Θ_{amb} ≤ 104 °F	≤ 0.5 %/10 K	
Frequency, range $0.98 \leq f/f_N \leq 1.02$ $0.95 \leq f/f_N \leq 1.05$	≤ 1 % of I_N ≤ 5 % of I_N	

Auto-reclosure *(ANSI 79)*	
Number of possible shots	1 to 9, configurable
Auto-reclosure modes	3-pole
Dead times for 1st and any further shot	0.05 s to 1800 s (steps 0.01 s)
Blocking time after successful AR	0.05 s to 320 s (steps 0.01 s)
Lock-out time after unsuccessful AR	0.05 s to 320 s (steps 0.01 s)
Reclaim time after manual close	0.50 s to 320 s (steps 0.01 s)
Duration of reclose command	0.01 s to 60 s (steps 0.01 s)

Trip circuit supervision *(ANSI 74TC)*	
Trip circuit supervision	With one or two binary inputs
Circuit-breaker trip test	Trip/reclosure cycle

Control	
Number of devices	1
Evaluation of breaker contact	None

Technical data

Motor protection	
Setting ranges/steps Rated motor current/ transformer rated current	I_{motor}/I_N = 0.2 to 1.2 (in steps of 0.1)
Start-up current of the motor	I_{start}/I_{motor} = 0.4 to 20 (in steps of 0.1)
Permissible start-up time $t_{start\ max}$	1 to 360 s (in steps of 0.1 s)
Starting time supervision (ANSI 48)	
Setting ranges/steps Pickup threshold	I_{pickup}/I_{motor} = 0.4 to 20 (in steps of 0.1)
Tripping time characteristic	$t_{TRIP} = \left(\frac{I_{start}}{I_{rms}}\right)^2 \cdot t_{start\ max}$ For $I_{rms} > I_{pickup}$ I_{start} = Start-up current of the motor I_{rms} = Current actually flowing I_{pickup} = Pickup threshold, from which the motor start-up is detected $t_{start\ max}$ = Maximum permissible starting time t_{TRIP} = Tripping time
Reset ratio I_{rms}/I_{pickup}	Approx. 0.94
Tolerances Pickup values	5 % of setting value or 5 % rated value
Delay time	5 % or 330 ms
Restart inhibit for motors (ANSI 66/86)	
Setting ranges/steps Rotor temperature compensation time T_{COMP}	0 to 60 min (in steps of 0.1min)
Minimum restart inhibit time $T_{restart}$	0.2 to 120 min (in steps of 0.1 min)
Maximum permissible number of warm starts n_w	1 to 4 (in steps of 1)
Difference between cold and warm start n_c - n_w	1 to 2 (in steps of 1)
Extension factor for cooling simulation of the rotor (running and stop)	1 to 10 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state
Undercurrent monitoring (ANSI 37)	
Threshold	$I_L < /I_N$ = 0.1 to 4 (in steps of 0.01)
Delay time for I_L<	0 to 320 s (in steps of 0.1 s)

Thermo-box (instead of system interface) (ANSI 38)	
Number of temperature sensors	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Installation drawing	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Limit values for indications For each measuring detector Warning temperature (stage 1)	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Alarm temperature (stage 2)	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

Additional functions	
Operational measured values	
For currents	I_{L1}, I_{L2}, I_{L3}, I_E in A (Amps) primary or in % I_N
Range	10 to 240 % I_N
Tolerance	3 % of measured value
For voltages	V_{L1-E}, in kV primary or in %
Range	10 to 120 % of V_N
Tolerance	≤ 3 % of measured value
For sensitive earth-current detection	I_{EE}, I_{EEac}, I_{EEreac} (r.m.s., active and reactive current) in A (kA) primary, or in %
Range	0 to 160 % I_{EEN}
Tolerance	≤ 3 % of measured value
Power/work	
S Apparent power	in kVA, MVA, GVA
S/VA (apparent power)	For V/V_N, I/I_N = 50 to 120 % typically < 6 %
P Active power,	in kW, MW, GW
P/Watts (active power)	For $\|\cos\varphi\|$ = 0.707 to 1, typically < 6 %, for V/V_N, I/I_N = 50 to 120 %
Q Reactive power,	In kvar, Mvar, Gvar
Q/Var (reactive power)	For $\|\sin\varphi\|$ = 0.707 to 1, typically < 6 %, for V/V_N, I/I_N = 50 to 120 %
cos φ, total and phase-selective	-1 to +1
Power factor cos φ	For $\|\cos\varphi\|$ = 0.707 to 1, typically < 5 %
Metering	
+ W_p kWh - W_p kWh + W_q kvarh - W_q kvarh	In kWh, MWh, GWh forward In kWh reverse In kvarh inductive In kvarh, Mvarh, Gvarh capacitive
Long-term mean values	
Mean values	15, 30, 60 minutes mean values
$I_{L1\ dmd}$ in A, kA $I_{L2\ dmd}$ in A, kA $I_{L3\ dmd}$ in A, kA	P_{dmd} in kW Q_{dmd} in kvar S_{dmd} in kVA

Technical data

Min/max. LOG (memory)	
Measured values	With date and time
Reset automatic	Time of day (settable in minutes) Time range (settable in days; 1 to 365, ∞)
Reset manual	Via binary input Via keyboard Via communication
Min./max. values of primary currents	I_{L1}; I_{L2}; I_{L3}
Min./max. values of primary voltages	$V_{L1\text{-}E}$
Min./max. values of power	S Apparent Power P Active power Q Reactive power Power factor cos φ
Min./max. values of primary currents mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}
Min./max. values of power mean value	P_{dmd}, Q_{dmd}, S_{dmd}
Fault event log	
Storage	Storage of the last 8 faults
Time assignment	
Resolution for operational indications	1 s
Resolution for fault event indications	1 ms
Max. time deviation	0.01 %
Fault recording	
Storage	Storage of max. 8 fault events
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 s to 5 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 s to 0.50 s (steps 0.01 s)
Post-fault time T_{post}	0.05 s to 0.50 s (steps 0.01 s)
Sampling rate at 50 Hz	1 instantaneous value per ms
Sampling rate at 60 Hz	1 instantaneous value per 0.83 ms
Backup battery	Lithium battery 3 V/1 Ah, type CR ½ AA Self-discharge time > 5 years "Battery fault" battery charge warning

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/ Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Selection and ordering data

Description	Order No.	Order code
7SJ602 multifunction overcurrent and motor protection relay	7SJ602☐ – ☐☐☐☐☐ – ☐☐☐☐ – ☐☐☐	
Measuring inputs (4 x I), default settings		
I_N = 1 A[1)], 15th position only with A	1	
I_N = 5 A[1)], 15th position only with A	5	
Measuring inputs (1 x V, 3 x I), default settings		See next page
I_{ph} = 1 A[1)], I_e = sensitive (I_{EE} = 0.003 to 1.5 A), 15th position only with B and J	2	
I_{ph} = 5 A[1)], I_e = sensitive (I_{EE} = 0.015 to 7.5 A), 15th position only with B and J	6	
Auxiliary voltage		
24/48 V DC, binary input threshold 19 V	2	
60/110 V DC[2)], binary input threshold 19 V[3)]	4	
110/125/220/250 V DC, 115/230 V AC[2)] binary input threshold 88 V[3)]	5	
Unit design		
Surface-mounting housing, terminals on top and bottom	B	
Flush-mounting housing, screw-type terminals	E	
Region-specific default and language settings		
Region World, 50/60 Hz, ANSI/IEC characteristic, languages: English, German, French, Spanish, Russian	B	
System port (on bottom of unit)		
No system port	0	
IEC 60870-5-103, electrical RS232	1	
IEC 60870-5-103, electrical RS485	2	
IEC 60870-5-103, optical 820 nm, ST connector	3	
Temperature monitoring box, electrical RS485[4)]	8	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector	9	L 0 E
Command (without process check back signal)		
Without command	0	
With command	1	
Measuring / fault recording		
Oscillographic fault recording	1	
Oscillographic fault recording, slave pointer, mean values, min./max. values	3	

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected in two stages by means of jumpers.

4) Temperature monitoring box 7XV5662-☐AD10, refer to part 14.

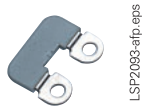
Selection and ordering data

Description		Order No.
7SJ602 multifunction overcurrent and motor protection relay		7SJ602□-□□□□□-□□□□
ANSI No.	**Description**	
	Basic version	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
50N/51N	Ground/earth-fault protection TOC ground/earth $I_E>$, $I_E>>$, I_{Ep}	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	F A [1]
	Basic version + directional ground/earth-fault detection	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
67Ns	Directional sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}	
64	Displacement voltage	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	F B [2]
	Basic version + sensitive ground/earth-fault detection + measuring	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
50Ns/51Ns	Sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	
	Voltage and power measuring	F J [2]
	Basic version + motor protection	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
50N/51N	Ground/earth-fault protection TOC ground/earth $I_E>$, $I_E>>$, I_{Ep}	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	
48	Starting time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	H A [1]
	Basic version + directional ground/earth fault protection + motor protection	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
67Ns	Directional sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}	
64	Displacement voltage	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	
48	Starting time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	H B [2]
	Basic version + sensitive ground/earth-fault detection + measuring + motor protection	
50/51	Time-overcurrent protection TOC phase	
	$I>$, $I>>$, $I>>>$, I_p, reverse interlocking	
50Ns/51Ns	Sensitive ground/earth-fault detection $I_{EE}>$, $I_{EE}>>$, I_{Ep}	
49	Overload protection	
74TC	Trip circuit supervision	
50BF	Breaker-failure protection	
	Cold load pickup	
46	Negative sequence/unbalanced load protection	
	Voltage and power measuring	
48	Starting time supervision	
37	Undercurrent/loss of load monitoring	
66/86	Restart inhibit	H J [2]
	Auto-reclosure (ARC)	
	Without auto-reclosure ARC	0
79	With auto-reclosure ARC	1

1) Only with position 7 = 1 or 5
2) Only with position 7 = 2 or 6

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition, device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows. Incl. templates, electronic manual with license for 10 PCs on CD-ROM. Authorization by serial number.	7XS5410-0AA00
Temperature monitoring box	
24 to 60 V AC/DC	7XV5662-2AD10
90 to 240 V AC/DC	7XV5662-5AD10
Connecting cable (contained in DIGSI 4, but can be ordered additionally) Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector)	7XV5100-4
Cable between temperature monitoring box and SIPROTEC 4 unit	
- length 5 m / 16.4 ft	7XV5103-7AA05
- length 25 m / 82 ft	7XV5103-7AA25
- length 50 m / 164 ft	7XV5103-7AA50
Manual for 7SJ602	
English	C53000-G1176-C125-4
Spanish	C53000-G1178-C125-2



Short-circuit links
for current terminals

Mounting rail

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 8-pole	C73334-A1-C32-1	1	Siemens
Short-circuit links			
For current terminals	C73334-A1-C33-1	1	Siemens
For other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

Your local Siemens representative
can inform you on local suppliers.

5

Connection diagram

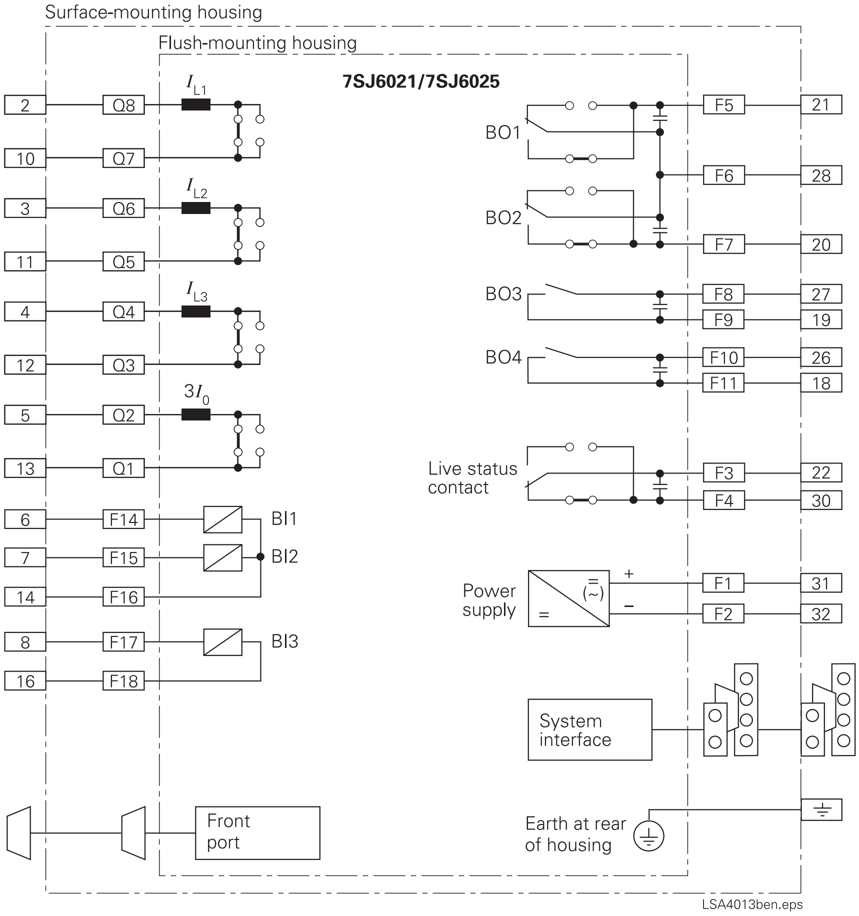


Fig. 5/54
Connection diagram according to IEC standard

Connection diagram

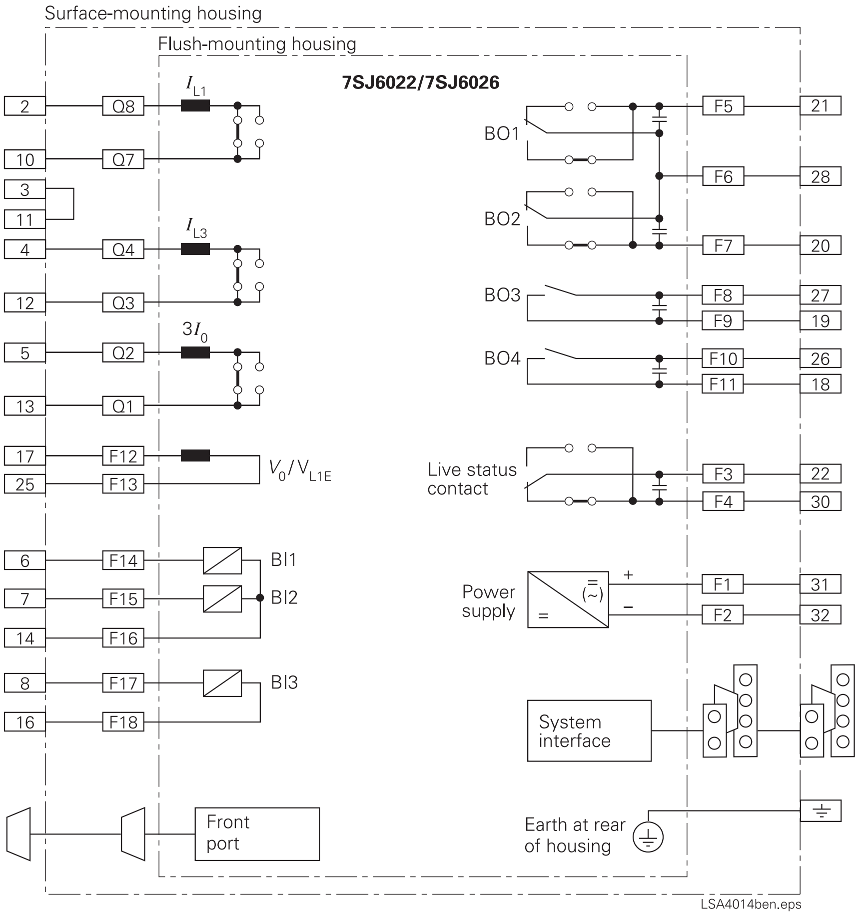


Fig. 5/55
Connection diagram according to IEC standard

5

SIPROTEC 4 7SJ61 Multifunction Protection Relay

Fig. 5/56 SIPROTEC 4 7SJ61 multifunction protection relay

Description

The SIPROTEC 4 7SJ61 relays can be used for line protection of high and medium voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point. When protecting motors, the SIPROTEC 4 7SJ61 is suitable for asynchronous machines of all sizes. The relay performs all functions of backup protection supplementary to transformer differential protection.

The relay provides control of the circuit-breaker, further switching devices and automation functions. The integrated programmable logic (CFC) allows the user to implement their own functions, e. g. for the automation of switchgear (interlocking). The user is also allowed to generate user-defined messages.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Time-overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive earth-fault detection
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
  - Undercurrent monitoring
  - Starting time supervision
  - Restart inhibit
  - Locked rotor
- Overload protection
- Temperature monitoring
- Breaker failure protection
- Negative-sequence protection
- Auto-reclosure
- Lockout

Control functions/programmable logic

- Commands for control of a circuit-breaker and of isolators
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values *I*
- Circuit-breaker wear monitoring
- Slave pointer
- Time metering of operating hours
- Trip circuit supervision
- 8 oscillographic fault records

Communication interfaces

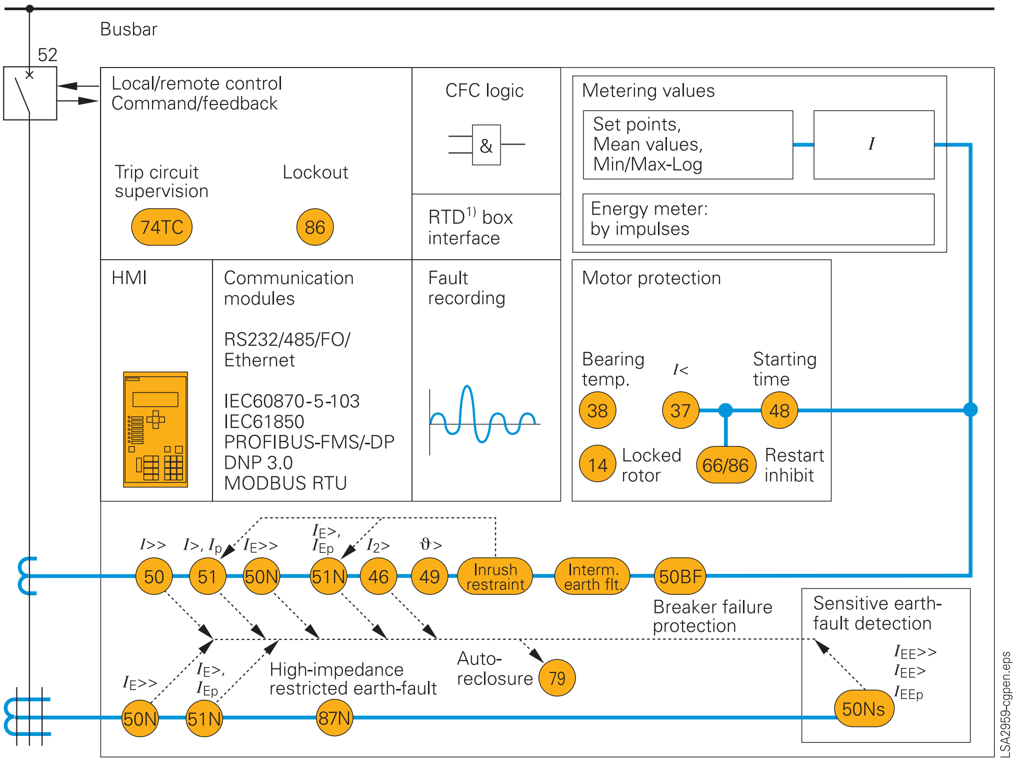
- System interface
  - IEC 60870-5-103, IEC 61850
  - PROFIBUS-FMS/-DP
  - DNP 3.0/MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Hardware

- 4 current transformers
- 3/8/11 binary inputs
- 4/8/6 output relays

5

Application



[1] RTD = resistance temperature detector

Fig. 5/57 Function diagram

The SIPROTEC 4 7SJ61 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read display was a major design aim.

Control

The integrated control function permits control of disconnect devices, earthing switches or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The relay is a non-directional overcurrent relay which can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point.

Motor protection

When protecting motors, the 7SJ61 relay is suitable for asynchronous machines of all sizes.

Transformer protection

The relay performs all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted earth-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The 7SJ61can be used universally for backup protection.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
50Ns, 51Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Sensitive earth-fault protection
–		Cold load pick-up (dynamic setting change)
–	$I_E>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring

Construction

Connection techniques and housing with many advantages

1/3-rack sizes is the available housing width of the 7SJ61 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housing for all housing widths. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

Fig. 5/58 Rear view with screw-type terminals

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Two definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

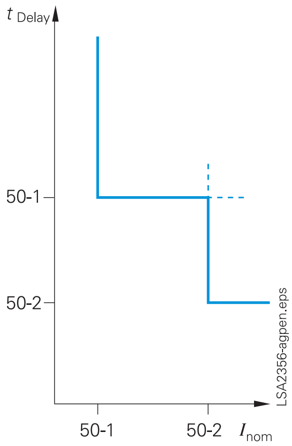


Fig. 5/59
Definite-time overcurrent protection

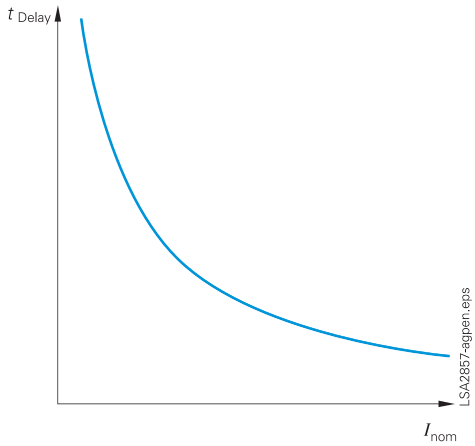


Fig. 5/60
Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and earth units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional normal elements (I>, I_p) are blocked.

Cold load pickup/dynamic setting change

For time-overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Protection functions

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns/50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short- circuit protection.

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if after a trip command, current is still flowing in the faulted circuit. As an option it is possible to make use of the circuit-breaker position indication.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-earth faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, earth short-circuit and phase-balance current protection.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The overcurrent elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the overcurrent elements can be activated depending on the ready AR

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD-box). The thermal replica of the

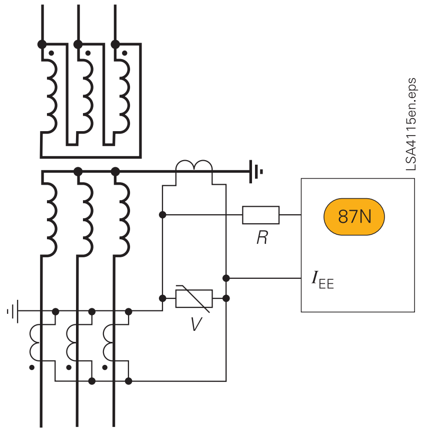


Fig. 5/61 High-impedance restricted earth-fault protection

overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

High-impedance restricted earth-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting earth faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an earthed network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high R whose voltage is measured (see Fig. 5/61). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor R at the sensitive current measurement input I_{EE}. The varistor V serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor R.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted earth-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

5

Protection functions/Functions

Motor protection

Starting time supervision (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups that might occur when excessive load torque occurs, excessive voltage drops occur within the motor or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\text{MOTOR START}}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\text{MOTOR START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Temperature monitoring (ANSI 38)

Up to 2 temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see “Accessories”, page 5/78).

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

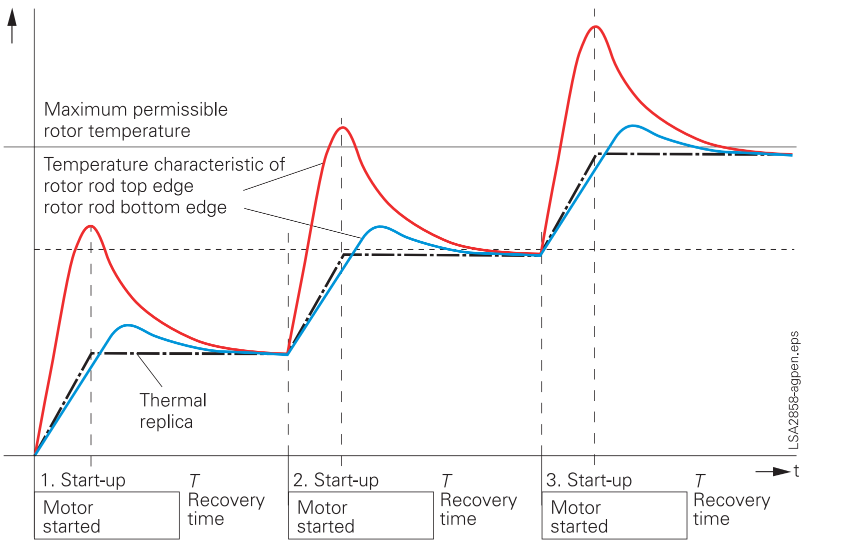


Fig. 5/62

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start- up (see Fig. 5/62).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, that can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/63) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Protection functions/Functions

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values.

To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ61 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

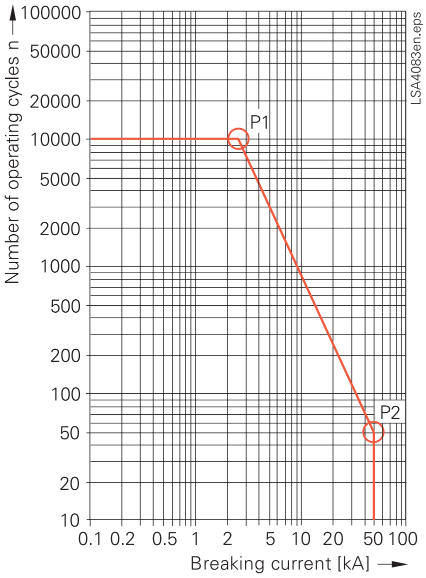


Fig. 5/63 CB switching cycle diagram

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Functions

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Measured values

The r.m.s. values are calculated from the acquired current. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (50Ns)
- Symmetrical components
  I_1, I_2, $3I_0$
- Mean as well as minimum and maximum current values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
- Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments or additional control components are necessary.

5

LSP2077f.eps

Fig. 5/64
NXAIR panel (air-insulated)

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user. The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

System interface protocols (retrofittable)

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized communication system (EN 50170) for efficient performance of communication tasks in the bay area. SIPROTEC 4 units use a profile specially optimized for protection and control requirements. DIGSI can also work on the basis of PROFIBUS-FMS. The units are linked to a SICAM automation system.

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

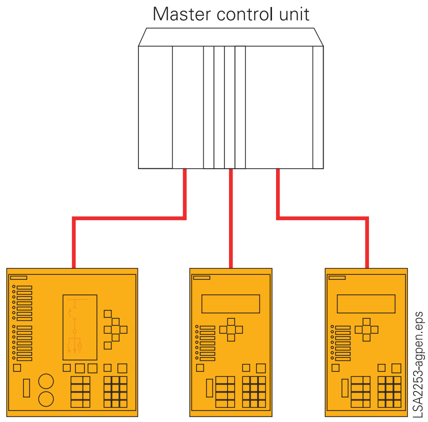


Fig. 5/65
IEC 60870-5-103: Radial fiber-optic connection

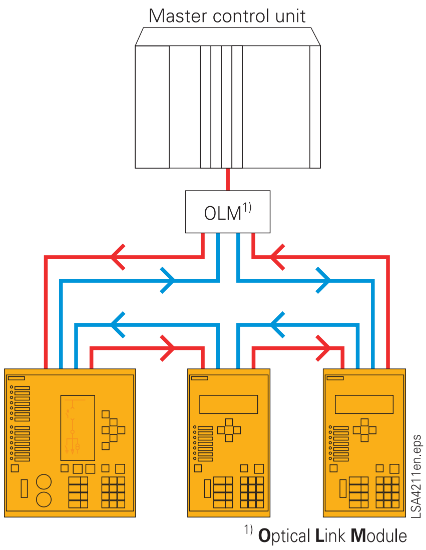


Fig. 5/66
PROFIBUS: Fiber-optic double ring circuit

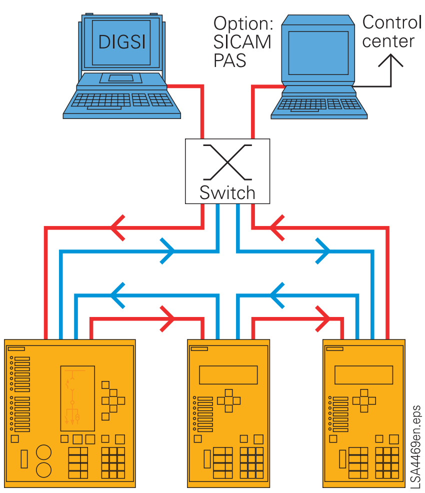


Fig. 5/67
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

1) For units in panel surface-mounting housings please refer to note on page 5/77.

Communication

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/65).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/67).

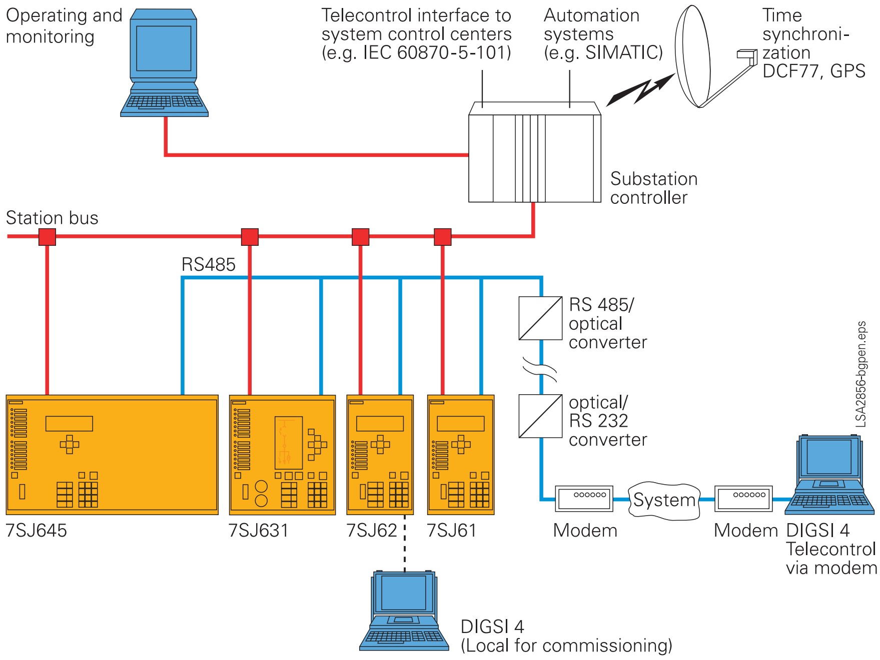


Fig. 5/68
System solution/communication

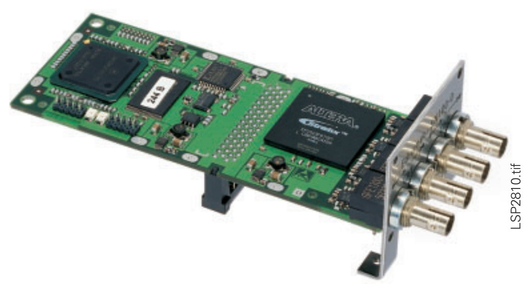


Fig. 5/69
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Typical connections

■ Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

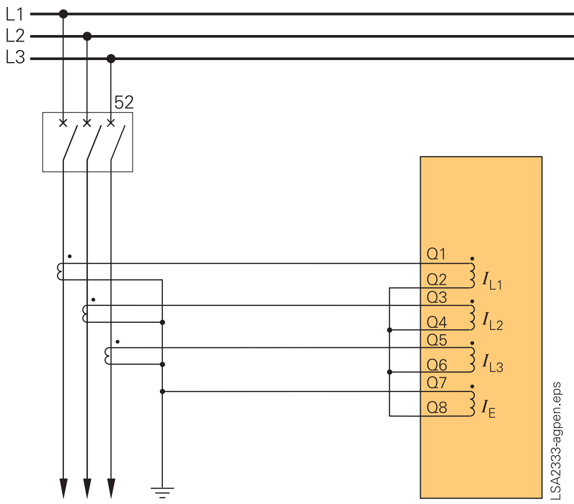


Fig. 5/70
Residual current circuit

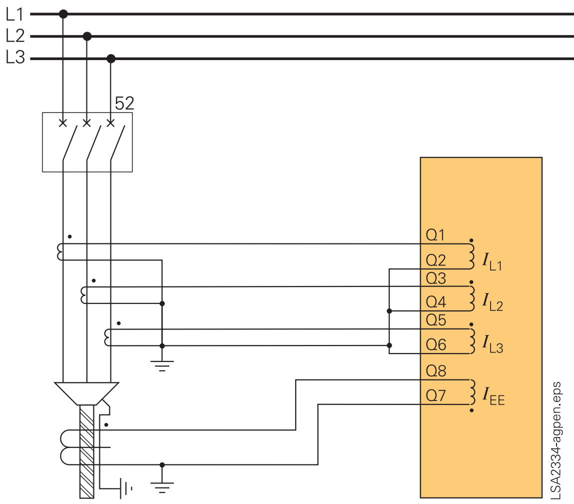


Fig. 5/71
Sensitive earth current detection

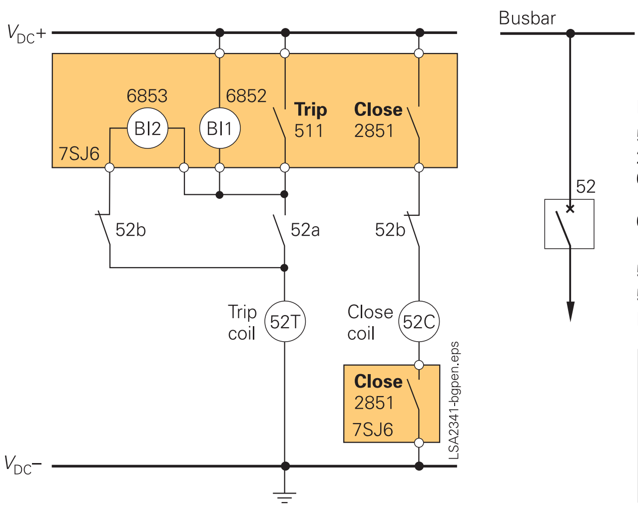
Typical applications

Overview of connection types

Type of network	Function	Current connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible
Isolated networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required
Compensated networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.



Protection indications

511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay
6853* Trip circuit supervision: CB aux

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/72 Trip circuit supervision with 2 binary inputs

Technical data

General unit data	
Measuring circuits	
System frequency	50 / 60 Hz (settable)
Current transformer	
Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A
Power consumption at I_{nom} = 1 A at I_{nom} = 5 A for sensitive earth-fault CT at 1 A	 Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective) Dynamic (impulse current)	 100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous 250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT Thermal (effective) Dynamic (impulse current)	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)

Auxiliary voltage (via integrated converter)				
Rated auxiliary voltage V_{aux}	DC AC	24/48 V	60/125 V	110/250 V 115/230 V
Permissible tolerance	DC AC	19–58 V	48–150 V	88–330 V 92–138 V 184–265 V
Ripple voltage, peak-to-peak	≤ 12 %			
Power consumption Quiescent Energized	 Approx. 3–4 W Approx. 7–9 W			
Backup time during loss/short-circuit of auxiliary voltage	≥ 50 ms at V ≥ 110 V DC ≥ 20 ms at V ≥ 24 V DC ≥ 200 ms at 115 V/230 V AC			

Binary inputs/indication inputs			
Type	7SJ610	7SJ611	7SJ612
Number	3	8	11
Voltage range	24–250 V DC		
Pickup threshold	Modifiable by plug-in jumpers		
Pickup threshold	DC 19 V		88 V
For rated control voltage	DC 24/48/60/110/125 V		110/220/250 V
Response time/drop-out time	Approx. 3.5 ms		
Power consumption energized	1.8 mA (independent of operating voltage)		

Binary outputs/command outputs			
Type	7SJ610	7SJ611	7SJ612
Number command/ indication relay	4	8	6
Contacts per command/ indication relay	1 NO / form A (2 contacts changeable to NC/form B, via jumpers)		
Live status contact	1 NO / NC (jumper) / form A / B		
Switching capacity Make	1000 W / VA		
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms		
Switching voltage	≤ 250 V DC		
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles		

Electrical tests	
Specification	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
Insulation tests	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
***EMC tests for interference immunity;** type tests*	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω

Technical data

Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
***EMC tests for interference emission;** type tests*	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
During transportation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!
Unit design	
Housing	7XP20
Dimensions	See dimension drawings, part 16
Weight Surface-mounting housing Flush-mounting housing	 4.5 kg 4.0 kg
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing Operator safety	 IP 51 Front: IP 51, rear: IP 20; IP 2x with cover

Serial interfaces	
***Operating interface** (front of unit)*	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	min. 4800 baud, max. 38400 baud
***Service/modem interface** (rear of unit)*	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Setting as supplied 38400 baud min. 4800 baud, max. 38400 baud
RS232/RS485	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	 9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

Technical data

System interface *(rear of unit)*	
IEC 60870-5-103 protocol	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Setting as supplied: 9600 baud, min. 9600 baud, max. 19200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
IEC 61850 protocol	
Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	Integr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Optical wavelength	1300 nm
Distance	1.5 km/0.9 miles
PROFIBUS-FMS/DP	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/77
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
MODBUS RTU, ASCII, DNP 3.0	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/77
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Technical data

Functions	
Definite-time overcurrent protection *(ANSI 50, 50N)*	
Operating mode phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase elements $I>$, $I>>$	0.5 to 175 A or ∞[1)] (in steps of 0.01 A)
Pickup earth elements $I_E>$, $I_E>>$	0.25 to 175 A or ∞[1)] (in steps of 0.01 A)
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times Pickup times (without inrush restraint, with inrush restraint + 10 ms)	
With twice the setting value	Approx. 30 ms
With five times the setting value	Approx. 20 ms
Dropout times	Approx. 40 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$
Tolerances Pickup	2 % of setting value or 50 mA[1)]
Delay times T, T_{DO}	1 % or 10 ms
Inverse-time overcurrent protection *(ANSI 51, 51N)*	
Operating mode phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or ∞ [1)] (in steps of 0.01 A)
Pickup earth element I_{EP}	0.25 to 20 A or ∞ [1)] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA[1)]
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

1) For I_{nom} = 1 A, all limits divided by 5.

Inrush blocking	
Influenced functions	Time-overcurrent elements, $I>$, $I_E>$, I_p, I_{Ep}
Lower function limit	1.25 A [1)]
Upper function limit (setting range)	1.5 to 125 A [1)] (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF
Dynamic setting change	
Controllable function	Pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)
(Sensitive) earth-fault detection *(ANSI 50 Ns, 51Ns)*	
Earth-fault pickup *for all types of earth faults*	
Definite-time characteristic *(ANSI 50Ns)*	
Setting ranges Pickup threshold $I_{EE}>$, $I_{EE}>>$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
Delay times T for $I_{EE}>$, $I_{EE}>>$	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times Pickup times	Approx. 60 ms (non-directional) Approx. 80 ms (directional
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold $I_{EE}>$, $I_{EE}>>$	2 % of setting value or 1 mA
Delay times	1 % of setting value or 20 ms
Earth-fault pickup *for all types of earth faults*	
Inverse-time characteristic *(ANSI 51Ns)*	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Logarithmic inverse	$t = T_{IEEpmax} - T_{IEEp} \cdot \ln \frac{I}{I_{EEp}}$
Setting ranges Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A[1)] (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Logarithmic inverse	
Time multiplier $T_{IEEp\ mul}$	0.05 to 15 s or ∞ (in steps of 0.01 s)
Delay time T_{IEEp}	0.1 to 4 s or ∞ (in steps of 0.01 s)
Min time delay $T_{IEEpmin}$	0 to 32 s (in steps of 0.01 s)
Max. time delay $T_{IEEpmax}$	0 to 32 s (in steps of 0.01 s)
Times Pickup times	Approx. 60 ms (non-directional) Approx 80 ms (directional)
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold I_{EEp}	2 % of setting value or 1 mA
Delay times in linear range	7 % of reference value for $2 \leq I/I_{EEp} \leq 20$ + 2 % current tolerance, or 70 ms

Technical data

High-impedance restricted earth-fault protection (ANSI 87N) / single-phase overcurrent protection	
Setting ranges	
Pickup thresholds $I>$, $I>>$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] or ∞ (in steps of 0.01 A)
Delay times $T_I>$, $T_I>>$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms

Intermittent earth-fault protection		
Setting ranges		
Pickup threshold		
For I_E	$I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For $3I_0$	$I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For I_{EE}	$I_{IE}>$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time	T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault		2 to 10 (in steps of 1)
Times		
Pickup times		
Current = 1.25 · pickup value		Approx. 30 ms
Current ≥ 2 · pickup value		Approx. 22 ms
Dropout time		Approx. 22 ms
Tolerances		
Pickup threshold $I_{IE}>$		3 % of setting value, or 50 mA[1]
Times T_V, T_{sum}, T_{res}		1 % of setting value or 10 ms

Thermal overload protection (ANSI 49)	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$
	t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8

Auto-reclosure (ANSI 79)	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements, negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements, sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command
Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

1) For I_{nom} = 1 A, all limits divided by 5.

5

Technical data

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4
(setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
$I>>, I>, I_p$,
$I_E>>, I_E>, I_{Ep}$

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

Breaker failure protection (ANSI 50 BF)

Setting ranges	
Pickup threshold CB $I>$	0.2 to 5 A[1] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
start via control	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)[1]
Delay time	1 % or 20 ms

Negative-sequence current detection (ANSI 46)

Definite-time characteristic (ANSI 46-1 and 46-2)

Setting ranges	
Pickup current $I_2>$, $I_2>>$	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A[1]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1]
Delay times	1 % or 10 ms

Inverse-time characteristic (ANSI 46-TOC)

Setting ranges	
Pickup current	0.5 to 10 A[1] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A[1]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors (ANSI 48)

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1] (in steps of 0.01)
Permissible starting time $T_{STARTUP}$	1 to 180 s (in steps of 0.1 s)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$ $I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1]
Delay time	5 % or 30 ms

Restart inhibit for motors (ANSI 66)

Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A[1] (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	3 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state

Undercurrent monitoring (ANSI 37)

Signal from the operational measured values	Predefined with programmable logic

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

Additional functions	
Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range Tolerance[1]	10 to 200 % I_{nom} 1 % of measured value or 0.5 % I_{nom}
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance[1]	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\ Trip}$	In %
Range Tolerance[1]	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\ Trip}$	In %
Reclose time $T_{Reclose}$	In min
Current of sensitive ground fault detection I_{EE}	In A (kA) primary and in mA secondary
Range Tolerance[1]	0 mA to 1600 mA 2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"
Long-term averages	
Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages of currents	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA)
Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3} I1 (positive-sequence component)
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component)

1) At rated frequency.

Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for I>$I_{balance\ limit}$
Current sum	$\lvert i_{L1} + i_{L2} + i_{L3} + k_{iE} \cdot i_E \rvert$ > limit value, with $k_{iE} = \frac{I_{earth}\text{ CT PRIM} / I_{earth}\text{ CT SEC}}{\text{CT PRIM} \ /\text{CT SEC}}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 5 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 sam/cyc) 1 sample/1.04 ms (16 sam/cyc)
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits
Circuit-breaker wear	
Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life)
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})

5

Technical data

Trip circuit monitoring	
With one or two binary inputs	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker / switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.
7SJ61 multifunction protection relay	*7SJ61□□ – □□□□□ – □□□□*

see next page

Housing, binary inputs (BI) and outputs (BO)

Housing 1/3 19", 3 BI, 4 BO, 1 live status contact	*0*
Housing 1/3 19", 8 BI, 8 BO, 1 live status contact	*1*
Housing 1/3 19", 11 BI, 6 BO, 1 live status contact	*2*

Measuring inputs (4 x I)

I_{ph} = 1 A[1)], I_e = 1 A[1)] (min. = 0.05 A) Position 15 only with *A*	*1*
I_{ph} = 1 A[1)], I_e = sensitive (min. = 0.001 A) Position 15 only with *B*	*2*
I_{ph} = 5 A[1)], I_e = 5 A[1)] (min. = 0.25 A) Position 15 only with *A*	*5*
I_{ph} = 5 A[1)], I_e = sensitive (min. = 0.001 A) Position 15 only with *B*	*6*
I_{ph} = 5 A[1)], I_e = 1 A[1)] (min. = 0.05 A) Position 15 only with *A*	*7*

Rated auxiliary voltage (power supply, indication voltage)

24 to 48 V DC, threshold binary input 19 DC[3)]	*2*
60 to 125 V DC[2)], threshold binary input 19 DC[3)]	*4*
110 to 250 V DC[2)], 115 to 230 V[4)] AC, threshold binary input 88 V DC[3)]	*5*

Unit version

For panel surface mounting, 2 tier terminal top/bottom	*B*
For panel flush mounting, plug-in terminal (2/3 pin connector)	*D*
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	*E*

Region-specific default settings/function versions and language settings

Region DE, 50 Hz, IEC, language: German, selectable	*A*
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	*B*
Region US, 60 Hz, ANSI, language: English (US), selectable	*C*
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	*D*
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	*E*

System interface (Port B): Refer to page 5/77

No system interface	*0*
Protocols see page 5/77	

Service interface (Port C)

No interface at rear side	*0*
DIGSI 4/modem, electrical RS232	*1*
DIGSI 4/modem/RTD-box[5)], electrical RS485	*2*
DIGSI 4/modem/RTD-box[5)6)], optical 820 nm wavelength, ST connector	*3*

Measuring/fault recording

Fault recording	*1*
Slave pointer, mean values, min/max values, fault recording	*3*

1) Rated current can be selected by means of jumpers.
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
3) The binary input thresholds can be selected per binary input by means of jumpers.
4) 230 V AC, starting from device version …/EE.
5) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".
6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

Selection and ordering data

Description			Order No.	Order code
7SJ61 multifunction protection relay			*7SJ61□□ – □□□□□ – □□□□–□□□□*	
Designation	**ANSI No.**	**Description**		
Basic version		Control		
	50/51	Time-overcurrent protection		
		$I>$, $I>>$, I_p, reverse interlocking		
	50N/51N	Earth-fault protection		
		$I_E>$, $I_E>>$, I_{Ep}		
	50N/51N	Earth-fault protection via insensitive		
		IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)		
	49	Overload protection (with 2 time constants)		
	46	Phase balance current protection		
		(negative-sequence protection)		
	50BF	Breaker failure protection		
	37	Undercurrent monitoring		
	74TC	Trip circuit supervision		
		4 setting groups, cold-load pickup		
		Inrush blocking		
	86	Lockout	F A	
■ IEF		Intermittent earth fault	P A	
■	50Ns/51Ns 87N	Sensitive earth-fault detection (non-directional) High-impedance restricted earth fault	F B 2)	
■ IEF	50Ns/51Ns 87N	Sensitive earth-fault detection (non-directional) High-impedance restricted earth fault Intermittent earth fault	P B 2)	
■ Motor IEF	50Ns/51Ns 87N 48/14 66/86	Sensitive earth-fault detection (non-directional) High-impedance restricted earth fault Intermittent earth fault Starting time supervision, locked rotor Restart inhibit	R B 2)	
■ Motor	50Ns/51Ns 87N 48/14 66/86	Sensitive earth-fault detection (non-directional) High-impedance restricted earth fault Starting time supervision, locked rotor Restart inhibit	H B 2)	
■ Motor	48/14 66/86	Starting time supervision, locked rotor Restart inhibit	H A	
ARC		Without	0	
	79	With auto-reclosure	1	
ATEX100 Certification For protection of explosion-protected motors (increased-safety type of protection "e")				Z X 9 9

■ Basic version included

IEF = Intermittent earth fault

1) 50N/51N only with insensitive earth-current transformer when position 7 = *1*, *5*, *7*.

2) Sensitive earth-current transformer only when position 7 = *2*, *6*.

Order numbers for system port B

Description	Order No.	Order code
7SJ61 multifunction protection relay	*7SJ61□□ – □□□□□ – □□□□–□□□*	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector [1])	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector [1])	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector [1])	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector [2])	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector [2])	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RSJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector (EN 100)[2])	9	L 0 S

1) Not with position 9 = "*B*"; if 9 = "*B*", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-3AB10, not available with position 9 = "*B*".
For double ring, please order converter 6GK1502-4AB10, not available with position 9 = "*B*".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).
2) Not available with position 9 = "*B*".

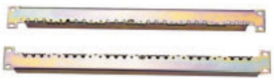
Sample order

Position		Order No. + Order code
		7SJ6125-5EC91-3FA1+L0G
6	I/O's: 11 BI/6 BO, 1 live status contact	2
7	Current transformer: 5 A	5
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	5
9	Unit version: Flush-mounting housing, screw-type terminals	E
10	Region: US, English language (US); 60 Hz, ANSI	C
11	Communication: System interface: DNP 3.0, RS485	9 L0G
12	Communication: DIGSI 4, electric RS232	1
13	Measuring/fault recording: Extended measuring and fault records	3
14/15	Protection function package: Basic version	FA
16	With auto-reclosure	1

Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for control displays), DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		7XS5460-0AA00
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		7XS5410-0AA00
Temperature monitoring box		
24 to 60 V AC/DC		7XV5662-2AD10
90 to 240 V AC/DC		7XV5662-5AD10
Varistor/Voltage Arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		C53207-A401-D76-1
240 Vrms; 600 A; 1S/S 1088		C53207-A401-D77-1
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		7XV5100-4
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		7XV5103-7AA05
- length 25 m /82 ft		7XV5103-7AA25
- length 50 m /164 ft		7XV5103-7AA50
Manual for 7SJ61		
English		C53000-G1140-C118-8
French		C53000-G1177-C118-1
Catalog SIP 3.1, Spanish		E50001-K4403-A111-A1-7800

Accessories


LSP2289-afp.eps

Mounting rail


LSP2090-afp.eps

2-pin connector


LSP2091-afp.eps

3-pin connector


LSP2093-afp.eps

Short-circuit links for current terminals


LSP2092-afp.eps

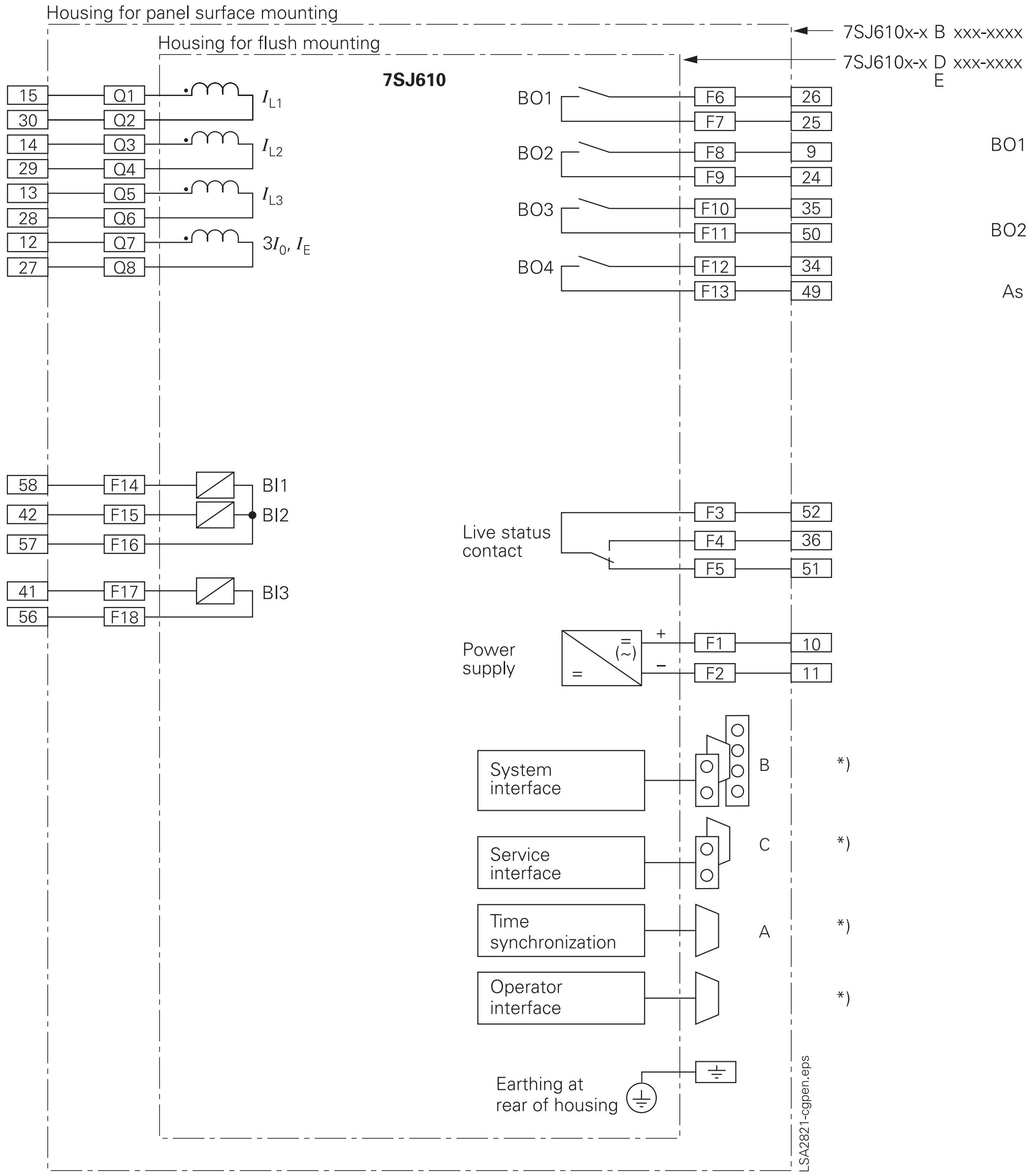
Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin	C73334-A1-C35-1	1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

5

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram



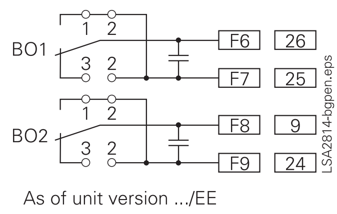
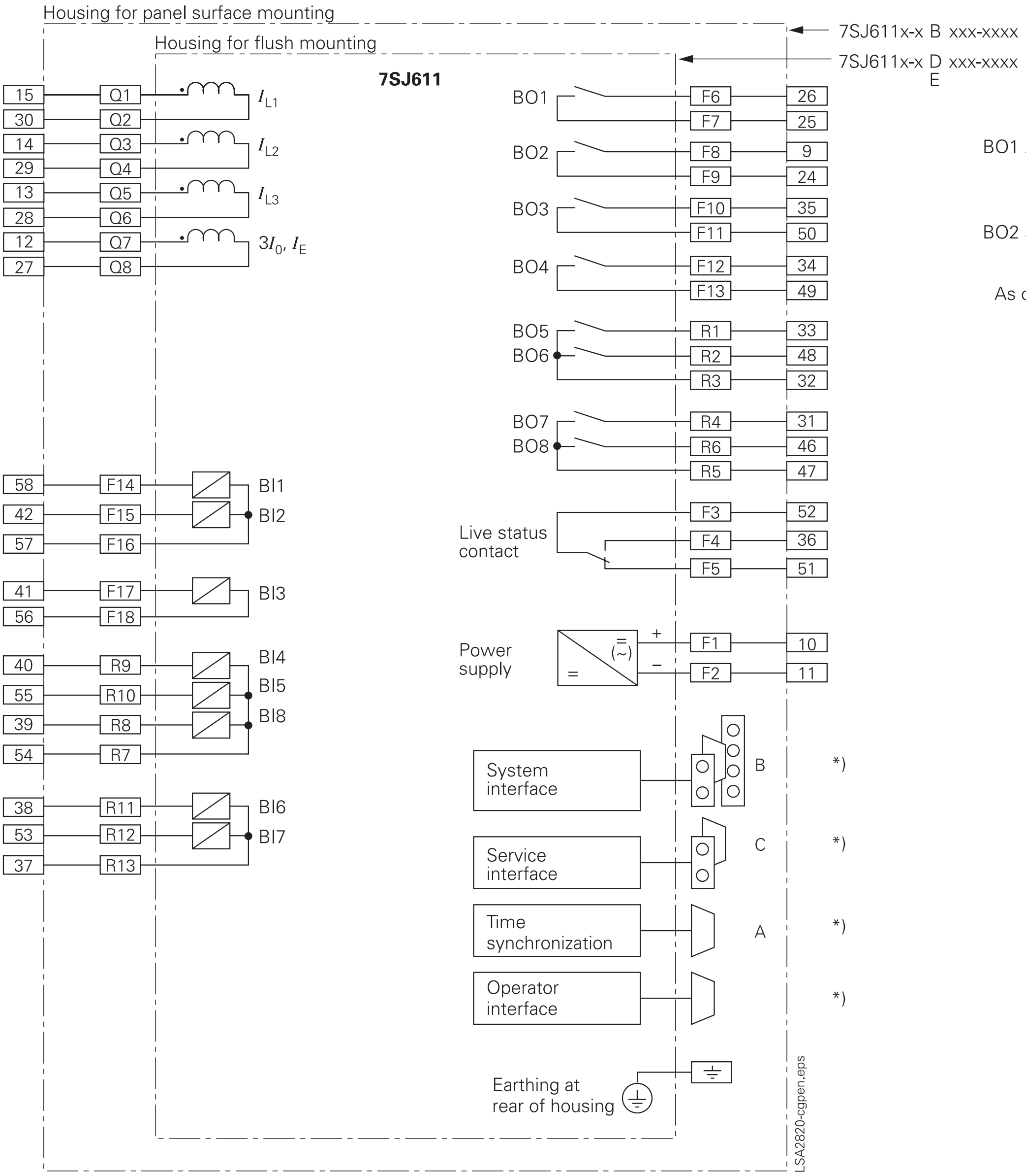


Fig. 5/73
7SJ610 connection diagram

*) For pinout of communication ports see part 16 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siprotec.com).

Connection diagram



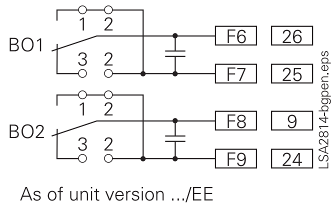
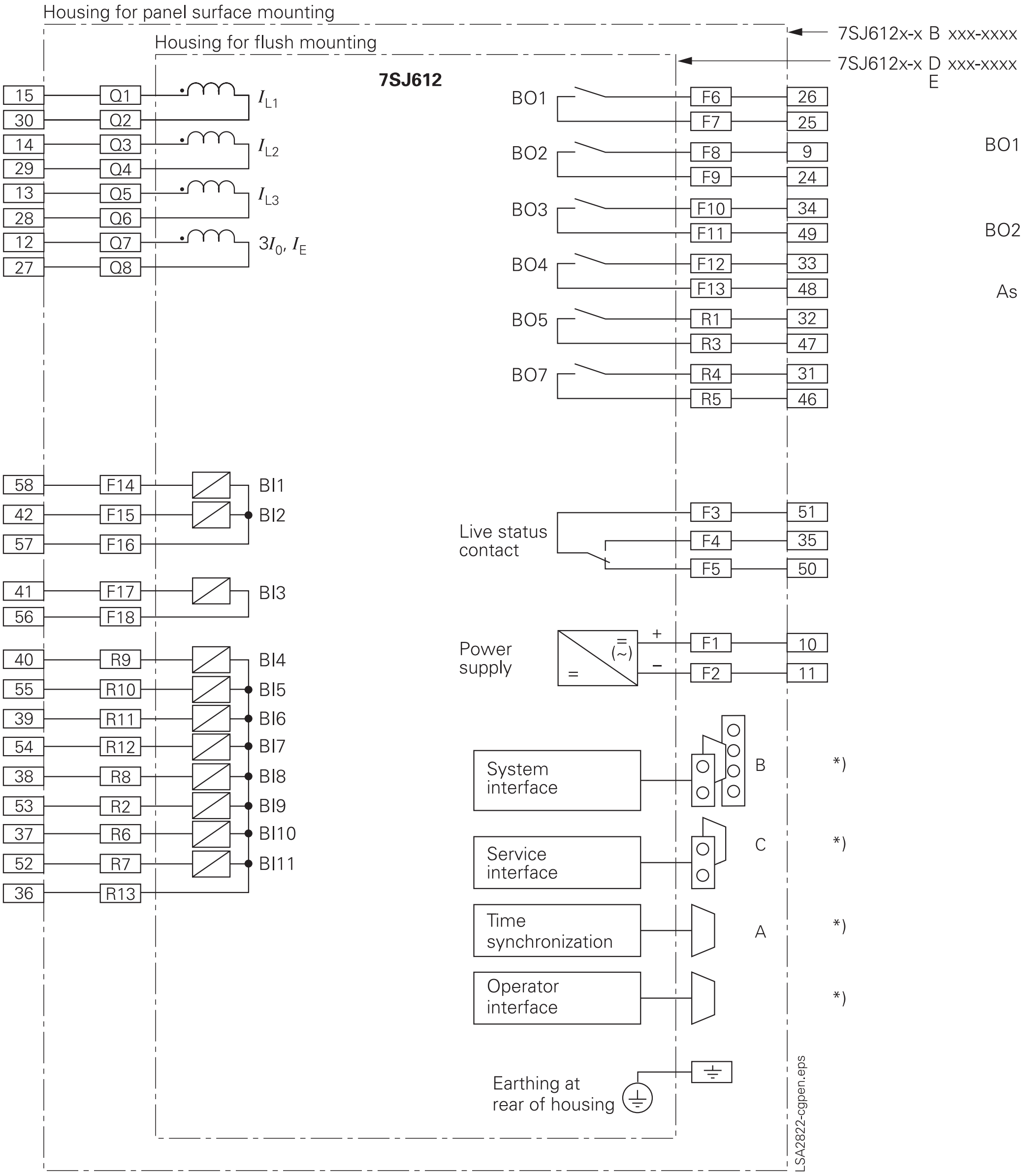


Fig. 5/74
7SJ611 connection diagram

*) For pinout of communication ports see part 16 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siprotec.com).

Connection diagram



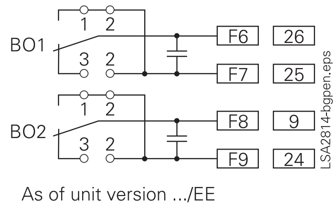


Fig. 5/75
7SJ612 connection diagram

*) For pinout of communication ports see part 16 of this catalog.
For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siprotec.com).

SIPROTEC 4 7SJ62 Multifunction Protection Relay

Fig. 5/76
SIPROTEC 7SJ62
multifunction protection relay

Description

The SIPROTEC 4 7SJ62 relays can be used for line protection of high and medium voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point. With regard to motor protection, the SIPROTEC 4 7SJ62 is suitable for asynchronous machines of all sizes. The relay performs all functions of backup protection supplementary to transformer differential protection.

The relay provides control of the circuit-breaker, further switching devices and automation functions. The integrated programmable logic (CFC) allows the user to implement their own functions, e. g. for the automation of switchgear (interlocking). The user is also allowed to generate user-defined messages.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Time-overcurrent protection (definite-time/inverse-time/user-def.)
- Directional time-overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive dir./non-dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
  - Undercurrent monitoring
  - Starting time supervision
  - Restart inhibit
  - Locked rotor
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Commands f. ctrl of CB and of isolators
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC (e.g. interlocking)

Monitoring functions

- Operational measured values V, I, f
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records

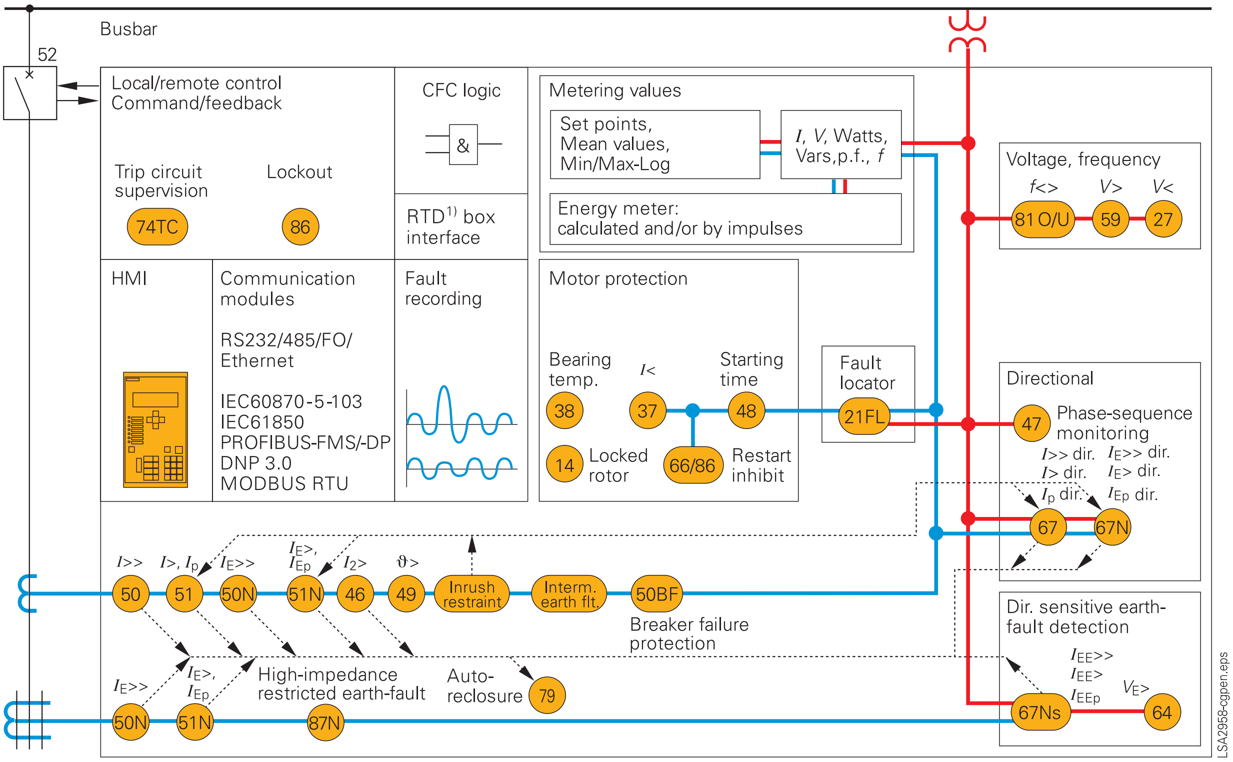
Communication interfaces

- System interface
  - IEC 60870-5-103/ IEC 61850
  - PROFIBUS-FMS/-DP
  - DNP 3.0/MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Hardware

- 4 current transformers
- 3 voltage transformers
- 8/11 binary inputs
- 8/6 output relays

Application



1) RTD = resistance temperature detector

Fig. 5/77 Function diagram

The SIPROTEC 4 7SJ62 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read display was a major design aim.

Control

The integrated control function permits control of disconnect devices, earthing switches or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The 7SJ62 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point.

Motor protection

When protecting motors, the 7SJ62 relay is suitable for asynchronous machines of all sizes.

Transformer protection

The relay performs all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted earth-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The 7SJ62can be used universally for backup protection.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$, $I_E>$, $I_E>>$	Definite time-overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse time-overcurrent protection (phase/neutral)
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\ dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\ dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	V_E, $V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase-sequence	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box), e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
21FL		Fault locator

Construction

Connection techniques and housing with many advantages

1/3-rack sizes is the available housing width of the 7SJ62 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housing for all housing widths. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

Fig. 5/78 Rear view with screw-type terminals

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Two definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

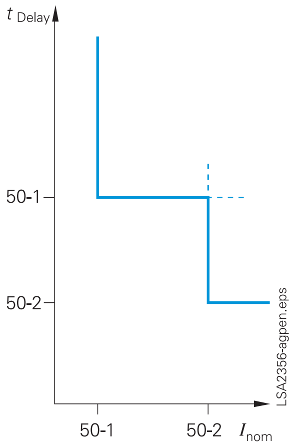


Fig. 5/79
Definite-time overcurrent protection

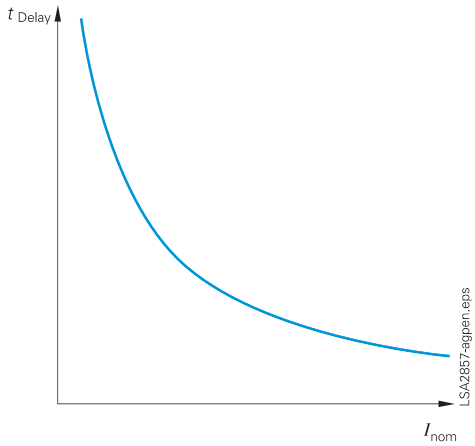


Fig. 5/80
Inverse-time overcurrent protection

5

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 /BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and earth units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and non-directional time-overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Protection functions

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristics are offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directionality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated time-overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequen- ce current I_0 and zero-sequence voltage V_0.

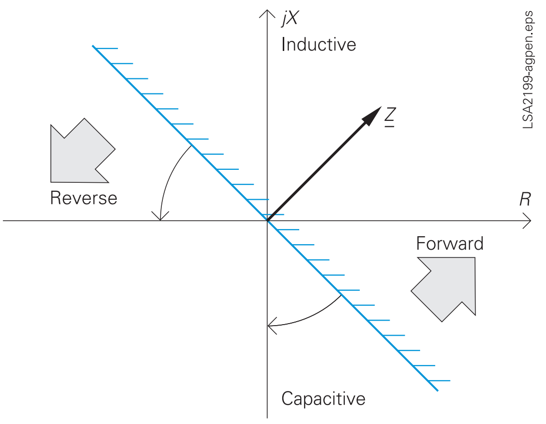


Fig. 5/81
Directional characteristic of the directional time-overcurrent protection

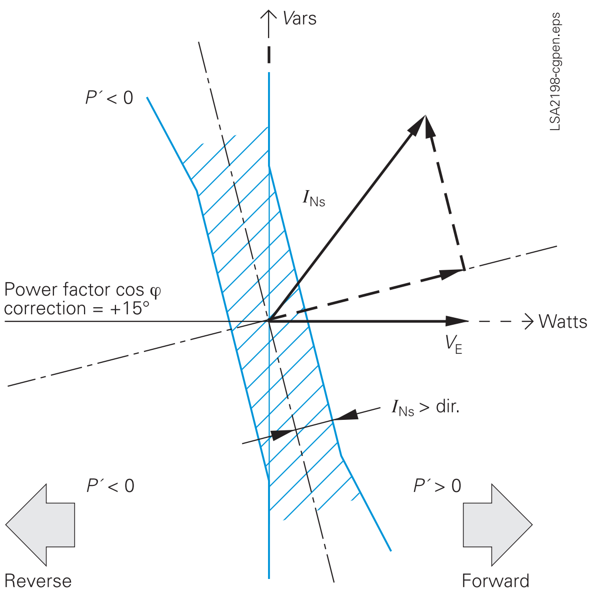


Fig. 5/82
Directional determination using cosine measurements for compensated networks

For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of earth-fault direction detection can be implemented: tripping or "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short-circuit protection.

Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold $I_{IE}>$ evaluates the r.m.s. value, referred to one systems period.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-earth faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

High-impedance restricted earth-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting earth faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an earthed network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high R whose voltage is measured (see Fig. 5/83). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor R at the sensitive current measurement input I_{EE}. The varistor V serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor R.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted earth-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

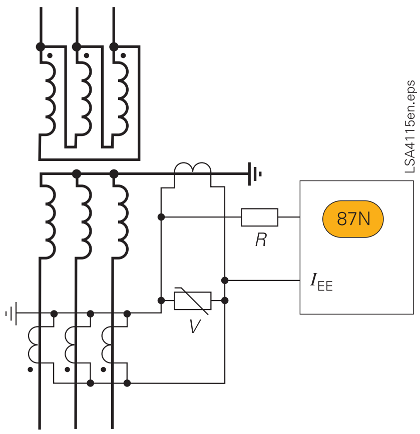


Fig. 5/83 High-impedance restricted earth-fault protection

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD- box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, earth short-circuit and phase-balance current protection.

Protection functions

Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/84).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see “Accessories”, page 5/113).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\mathrm{MOTOR\ START}}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I	=	Actual current flowing
$I_{\mathrm{MOTOR\ START}}$	=	Pickup current to detect a motor start
t	=	Tripping time
I_A	=	Rated motor starting current
T_A	=	Tripping time at rated motor starting current

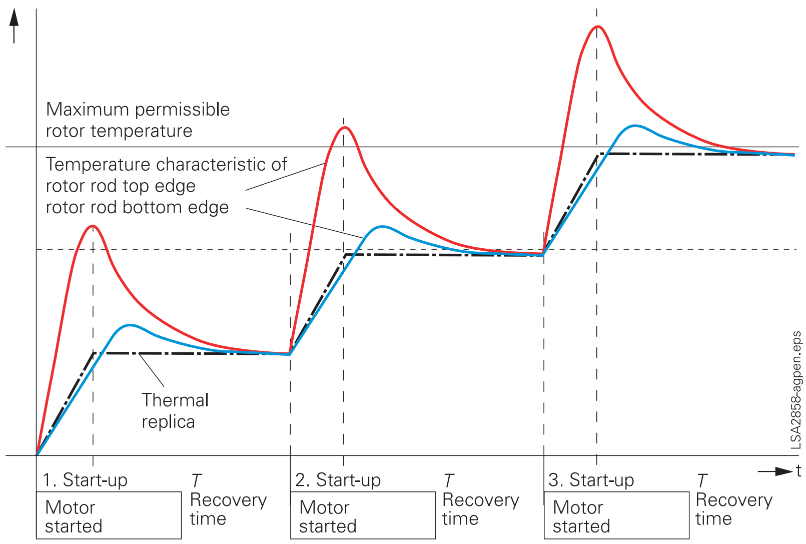


Fig. 5/84

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase voltage (default) or with the negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)[1)]. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with the positive phase-sequence system voltage (default) or with the phase-to-phase voltages, and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting.

1) The 45 to 55, 55 to 65 Hz range is available for f_N = 50/60 Hz.

Protection functions/Functions

Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The fault locator specifies the distance to a fault location in kilometers or miles or the reactance of a second fault operation.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/85) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

1) The 45 to 55, 55 to 65 Hz range is available for f_N= 50/60 Hz

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ62 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:
– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

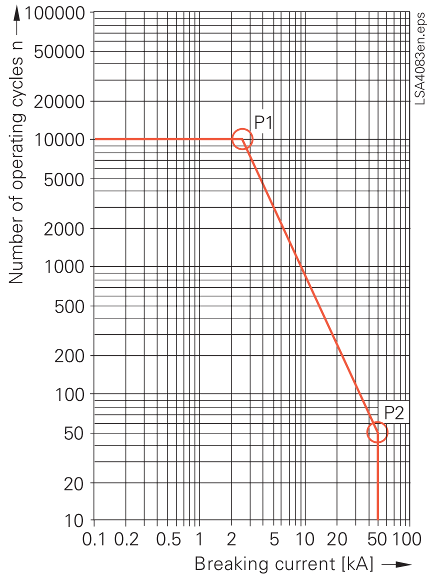


Fig. 5/85 CB switching cycle diagram

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).
If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches

Functions

- Triggering of switching operations, indications or alarm by combination with existing information

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g., for current, voltage, frequency, …) or additional control components are necessary.

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase selective)
- Power factor ($\cos\varphi$), (total and phase selective)
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

LSP2077f.eps

Fig. 5/86
NXAIR panel (air-insulated)

5

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user. The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

1) For units in panel surface-mounting housings please refer to note on page 5/112.

System interface protocols (retrofittable)

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized communication system (EN 50170) for efficient performance of communication tasks in the bay area. SIPROTEC 4 units use a profile specially optimized for protection and control requirements. DIGSI can also work on the basis of PROFIBUS-FMS. The units are linked to a SICAM automation system.

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

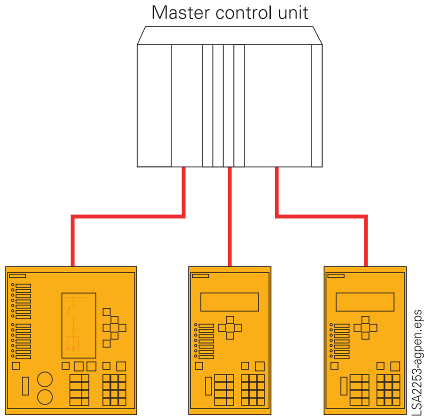


Fig. 5/87
IEC 60870-5-103: Radial fiber-optic connection

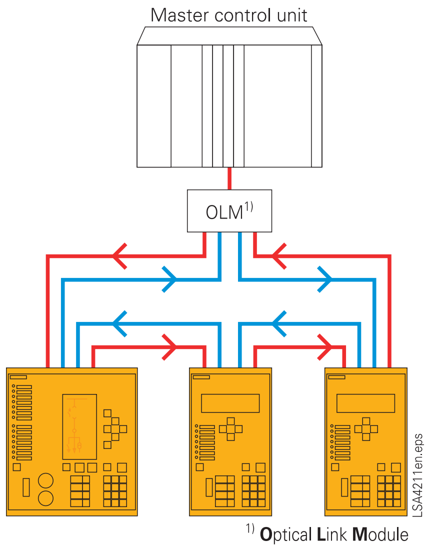


Fig. 5/88
PROFIBUS: Fiber-optic double ring circuit

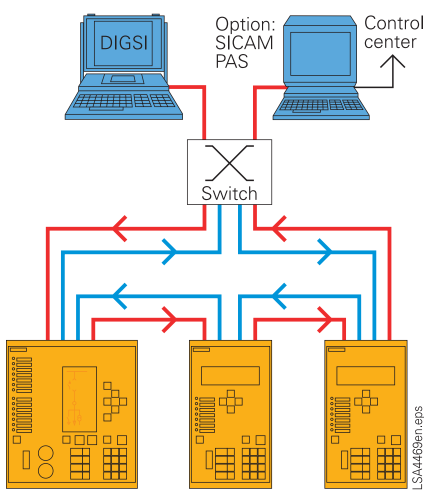


Fig. 5/89
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

Communication

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/87).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/89).

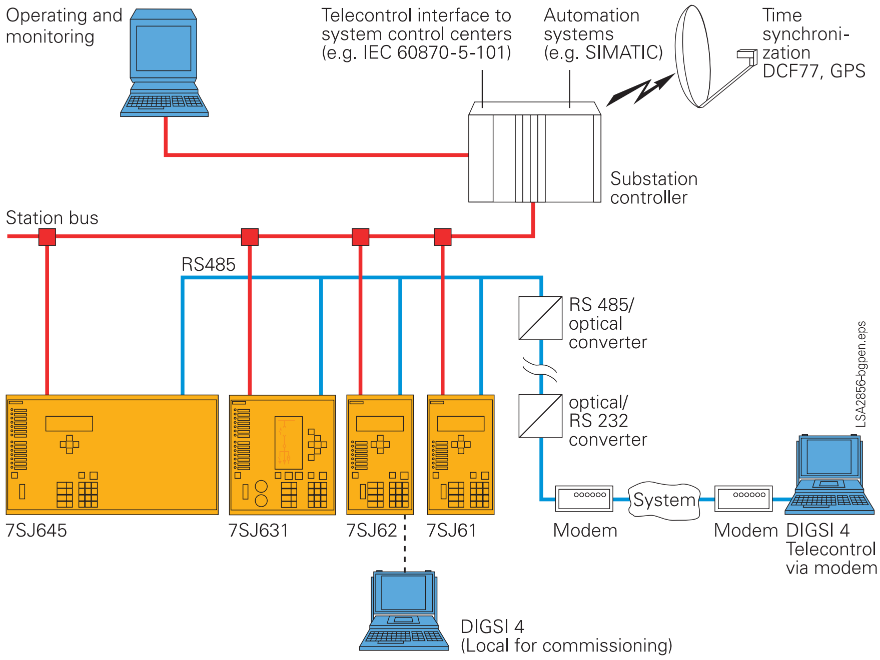


Fig. 5/90
System solution/communication

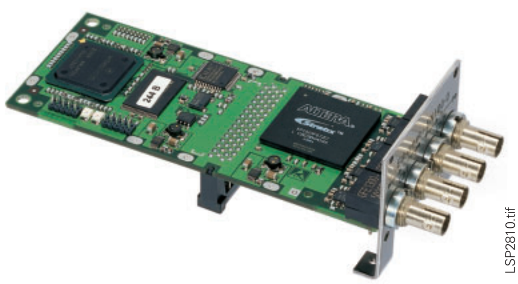


Fig. 5/91
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Typical connections

■ Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

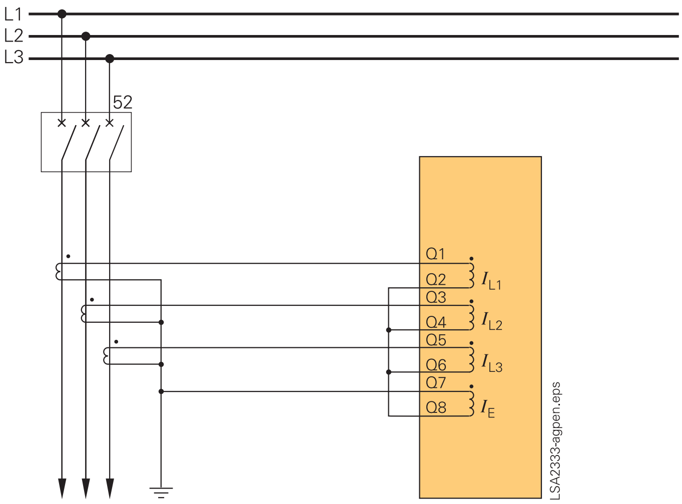


Fig. 5/92
Residual current circuit without directional element

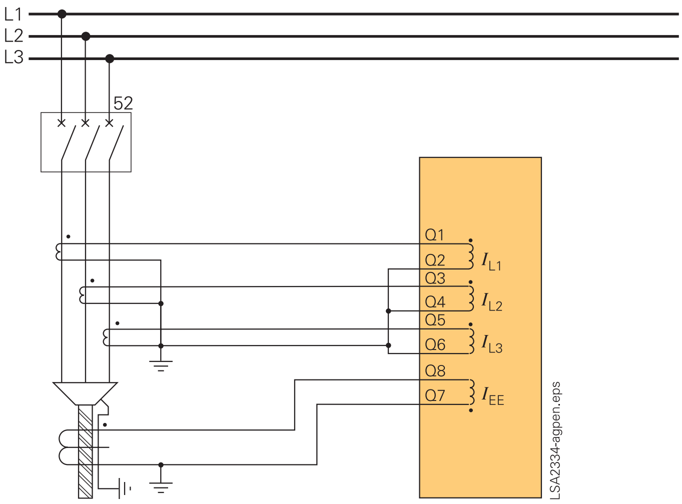


Fig. 5/93
Sensitive earth-current detection without directional element

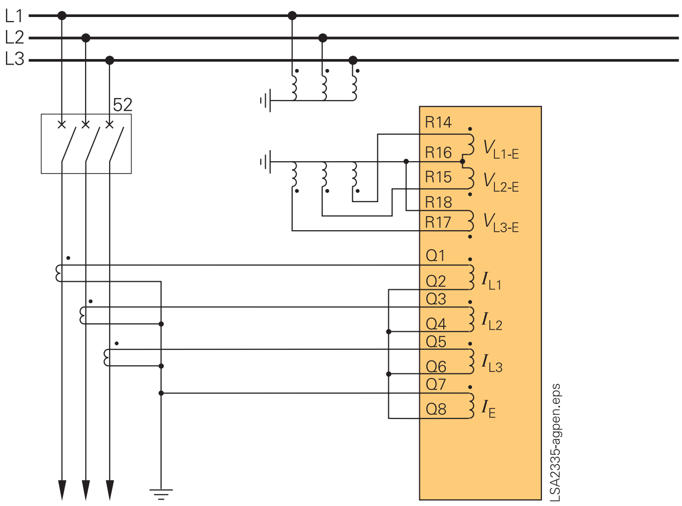


Fig. 5/94
Residual current circuit with directional element

Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the earth current. This connection maintains maximum precision for directional earth-fault detection and must be used in compensated networks.
Fig. 5/95 shows sensitive directional earth-fault detection.

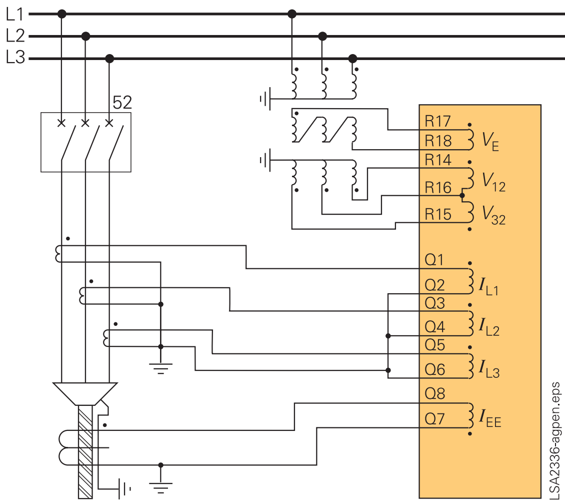


Fig. 5/95
Sensitive directional earth-fault detection with directional element for phases

5

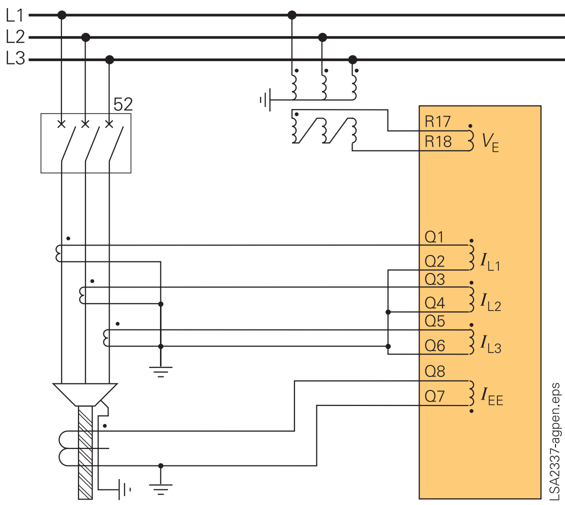


Fig. 5/96
Sensitive directional earth-fault detection

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

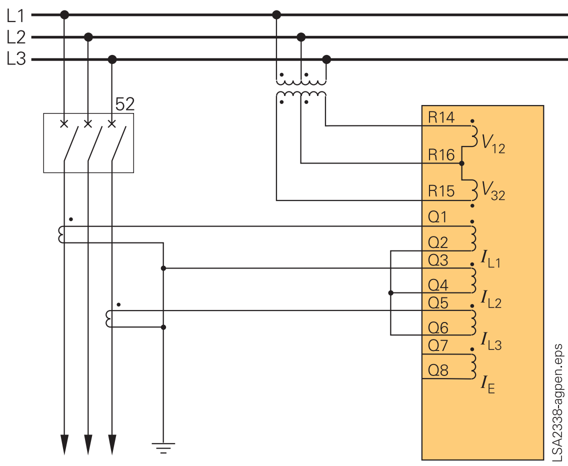


Fig. 5/97
Isolated-neutral or compensated networks

Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current > 0.05 I_N on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/98, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of network fault.

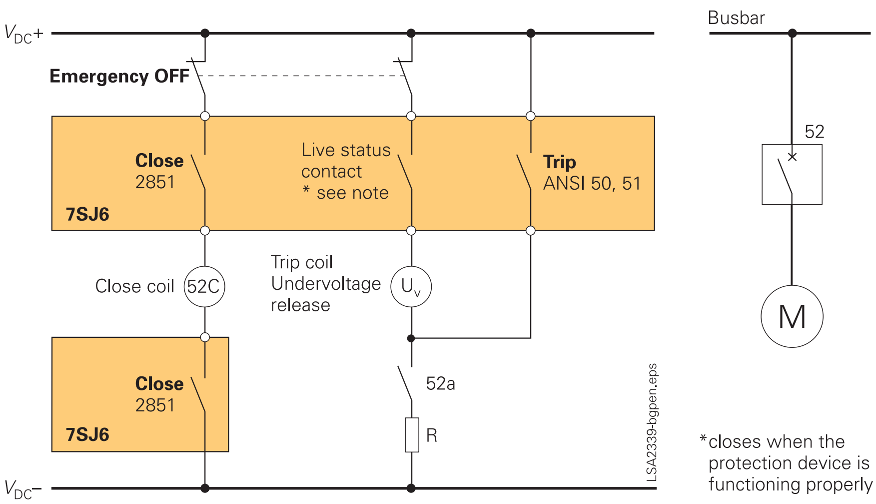


Fig. 5/98 Undervoltage release with make contact (50, 51)

Typical applications

In Fig. 5/99 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

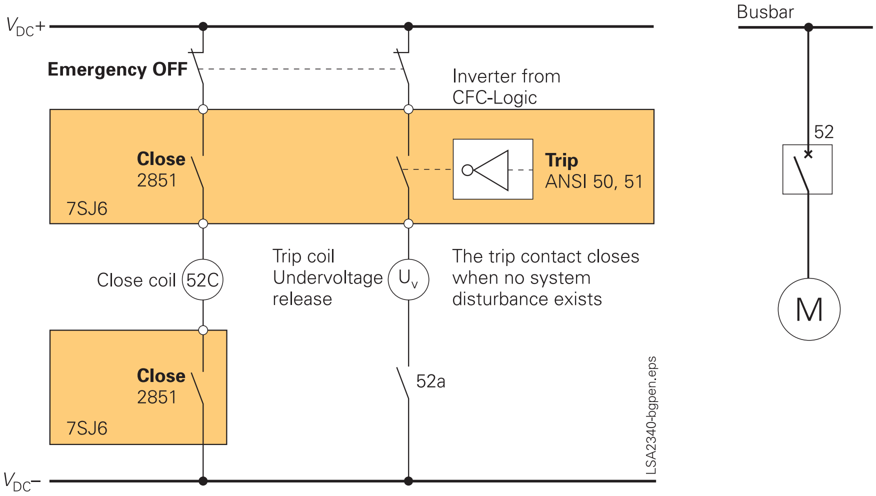
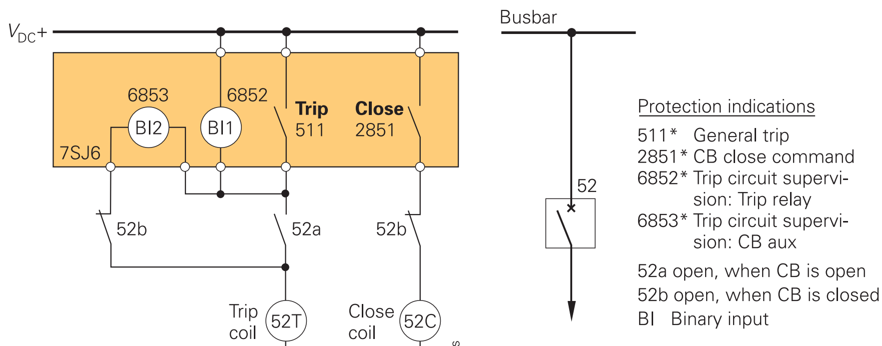
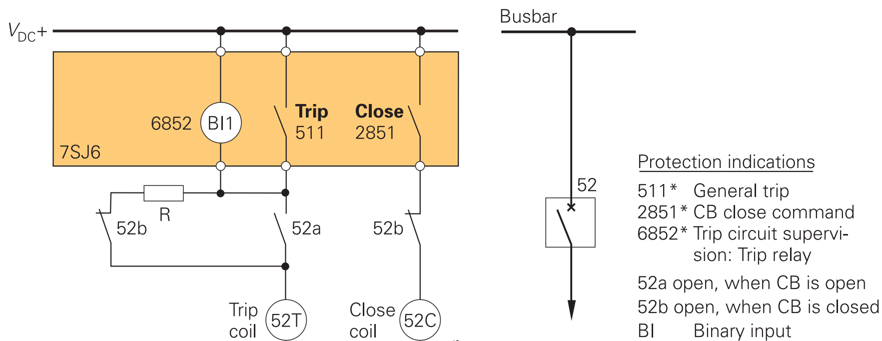


Fig. 5/99 Undervoltage trip with locking contact (trip signal 50 is inverted)



TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/100 Trip circuit supervision with 2 binary inputs



TRIP contact	Breaker	BI1
open	closed	H
open	open	H
closed	closed	L
closed	open	L

Fig. 5/101 Trip circuit supervision with 1 binary input

5

Technical data

General unit data	
Measuring circuits	
System frequency	50 / 60 Hz (settable)
Current transformer	
Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A
Power consumption at I_{nom} = 1 A at I_{nom} = 5 A for sensitive earth-fault CT at 1 A	 Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA
Overload capability Thermal (effective) Dynamic (impulse current)	 100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous 250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT Thermal (effective) Dynamic (impulse current)	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)
Voltage transformer	
Rated voltage V_{nom}	100 V to 225 V
Power consumption at V_{nom} = 100 V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage) Thermal (effective)	 230 V continuous

Auxiliary voltage					
Rated auxiliary voltage V_{aux}	DC AC	24/48 V	60/125 V	110/250 V 115/230 V	
Permissible tolerance	DC AC	19–58 V	48–150 V	88–300 V 92-138 V	 184–265 V
Ripple voltage, peak-to-peak	≤ 12 %				
Power consumption Quiescent Energized	 Approx. 3–4 W Approx. 7–9 W				
Backup time during loss/short circuit of auxiliary voltage	≥ 50 ms at V ≥ 110 V DC ≥ 20 ms at V ≥ 24 V DC ≥ 200 ms at 115 V/230 V AC				

Binary inputs/indication inputs		
Type	7SJ621	7SJ622
Number	8	11
Voltage range	24–250 V DC	
Pickup threshold modifiable by plug-in jumpers		
Pickup threshold	19 V DC	88 V DC
For rated control voltage	24/48/60/ 110/125 V	110/125/ 220/250 V DC
Response time/drop-out time	Approx. 3.5	
Power consumption energized	1.8 mA (independent of operating voltage)	

Binary outputs/command outputs		
Type	7SJ621	7SJ622
Command/indication relay	8	6
Contacts per command/ indication relay	1 NO / form A (Two contacts changeable to NC/form B, via jumpers)	
Live status contact	1 NO / NC (jumper) / form A/B	
Switching capacity Make Break	 1000 W / VA 30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms	
Switching voltage	≤ 250 V DC	
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles	

Electrical tests	
Specification	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
Insulation tests	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for interference immunity; type tests	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min

Technical data

High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
***EMC tests for interference emission;** type tests*	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests

Vibration, shock stress and seismic vibration	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
<u>During transportation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

Climatic stress tests

Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design

Housing	7XP20
Dimensions	See dimension drawings, part 16
Weight Surface-mounting housing Flush-mounting housing	 4.5 kg 4.0 kg
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing Operator safety	 IP 51 Front: IP 51, rear: IP 20; IP 2x with cover

Technical data

Serial interfaces	
***Operating interface** (front of unit)*	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	min. 4800 baud, max. 38400 baud
***Service/modem interface** (rear of unit)*	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Setting as supplied 38400 baud min. 4800 baud, max. 38400 baud
RS232/RS485	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
***System interface** (rear of unit)*	
IEC 60870-5-103 protocol	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Setting as supplied: 9600 baud, min. 9600 baud, max. 19200 baud
RS232/RS485	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
IEC 61850 protocol	
Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	Intergr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles
PROFIBUS-FMS/DP	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud
RS485	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes [1] and [2] on page 5/112
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
MODBUS RTU, ASCII, DNP 3.0	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
RS485	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “B”
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Test voltage	500 V AC against earth

5

Technical data

Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes [1] and [2] on page 5/112
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Functions

Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)		
Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)	
Setting ranges		
Pickup phase elements $I>$, $I>>$	0.5 to 175 A or ∞[1] (in steps of 0.01 A)	
Pickup earth elements $I_E>$, $I_E>>$	0.25 to 175 A or ∞[1] (in steps of 0.01 A)	
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)	
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)	
Times		
Pickup times (without inrush restraint, with inrush restraint + 10 ms)		
	Non-directional	Directional
With twice the setting value	Approx. 30 ms	45 ms
With five times the setting value	Approx. 20 ms	40 ms
Dropout times	Approx. 40 ms	
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$	
Tolerances		
Pickup	2 % of setting value or 50 mA[1]	
Delay times T, T_{DO}	1 % or 10 ms	
Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)		
Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)	
Setting ranges		
Pickup phase element I_P	0.5 to 20 A or ∞ [1] (in steps of 0.01 A)	
Pickup earth element I_{EP}	0.25 to 20 A or ∞ [1] (in steps of 0.01 A)	
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)	
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)	

1) At I_{nom} = 1 A, all limits divided by 5.

Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA[1]
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For earth faults	
Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	
Zero-sequence quantities $3V_0$, $3I_0$	$V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative -sequence quantities $3V_2$, $3I_2$	$3V_2 \approx 5$ V negative-sequence voltage; $3I_2 \approx 225$ mA negative-sequence current[1]
Tolerances (phase angle error under reference conditions)	
For phase and earth faults	± 3 ° electrical
Inrush blocking	
Influenced functions	Time-overcurrent elements, $I>$, $I_E>$, I_p, I_{Ep} (directional, non-directional)
Lower function limit	1.25 A [1]
Upper function limit (setting range)	1.5 to 125 A [1] (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF

5

5

Technical data

Dynamic setting change	
Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)
***(Sensitive) earth-fault detection** (ANSI 64, 50 Ns, 51Ns, 67Ns)*	
***Displacement voltage starting** for all types of earth fault (ANSI 64)*	
Setting ranges	
Pickup threshold V_E> (measured)	1.8 to 170 V (in steps of 0.1 V)
Pickup threshold $3V_0$> (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{Delay\ pickup}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 60 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms
Phase detection for earth fault in an unearthed system	
Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges	
$V_{ph\ min}$ (earth-fault phase)	10 to 100 V (in steps of 1 V)
$V_{ph\ max}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V
***Earth-fault pickup** for all types of earth faults*	
***Definite-time characteristic** (ANSI 50Ns)*	
Setting ranges	
Pickup threshold I_{EE}>, I_{EE}>>	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
Delay times T for I_{EE}>, I_{EE}>>	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 60 ms (non-directional) Approx. 80 ms (directional
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold I_{EE}>, I_{EE}>>	2 % of setting value or 1 mA
Delay times	1 % of setting value or 20 ms

1) For I_{nom} = 1 A, all limits divided by 5.

***Earth-fault pickup** for all types of earth faults*	
***Inverse-time characteristic** (ANSI 51Ns)*	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Logarithmic inverse	$t = T_{IEEpmax} - T_{IEEp} \cdot \ln \frac{I}{I_{EEp}}$
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A[1)] (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Logarithmic inverse	
Time multiplier $T_{IEEp\ mul}$	0.05 to 15 s or ∞ (in steps of 0.01 s)
Delay time T_{IEEp}	0.1 to 4 s or ∞ (in steps of 0.01 s)
Min time delay $T_{IEEpmin}$	0 to 32 s (in steps of 0.01 s)
Max. time delay $T_{IEEpmax}$	0 to 32 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 60 ms (non-directional) Approx 80 ms (directional)
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold I_{EEp}	2 % of setting value or 1 mA
Delay times in linear range	7 % of reference value for 2 ≤ I/I_{EEp} ≤ 20 + 2 % current tolerance, or 70 ms
***Direction detection** for all types of earth-faults (ANSI 67Ns)*	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct.}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A[1)] (in steps of 0.01 A)
Measuring method	cos φ and sin φ
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Angle correction for cable CT	
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current value $I1$, $I2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
Tolerances	
Pickup measuring enable	2 % of the setting value or 1 mA
Angle tolerance	3 °

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

Technical data

High-impedance restricted earth-fault protection (ANSI 87N) / single-phase overcurrent protection	
Setting ranges	
Pickup thresholds $I>$, $I>>$	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] or ∞ (in steps of 0.01 A)
Delay times $T_I>$, $T_I>>$	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms

Intermittent earth-fault protection		
Setting ranges		
Pickup threshold		
For I_E	$I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For $3I_0$	$I_{IE}>$	0.25 to 175 A[1] (in steps of 0.01 A)
For I_{EE}	$I_{IE}>$	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time	T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault		2 to 10 (in steps of 1)
Times		
Pickup times		
Current = 1.25 · pickup value		Approx. 30 ms
Current ≥ 2 · pickup value		Approx. 22 ms
Dropout time		Approx. 22 ms
Tolerances		
Pickup threshold $I_{IE}>$		3 % of setting value, or 50 mA [1]
Times T_V, T_{sum}, T_{res}		1 % of setting value or 10 ms

1) For I_{nom} = 1 A, all limits divided by 5.

Thermal overload protection (ANSI 49)	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \frac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8

Auto-reclosure (ANSI 79)	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command

5

Technical data

Auto-reclosure *(cont'd)*	
Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
I>>, I>, I_p, I_{dir}>>, I_{dir}>, I_{pdir}
I_E>>, I_E>, I_{Ep}, I_{Edir}>>, I_{Edir}>, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

Breaker failure protection *(ANSI 50 BF)*	
Setting ranges	
Pickup threshold CB I>	0.2 to 5 A[1)] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
start via control	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)[1)]
Delay time	1 % or 20 ms

Negative-sequence current detection *(ANSI 46)*	
Definite-time characteristic *(ANSI 46-1 and 46-2)*	
Setting ranges	
Pickup current I_2>, I_2>>	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A[1)]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2/I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1)]
Delay times	1 % or 10 ms
Inverse-time characteristic *(ANSI 46-TOC)*	
Setting ranges	
Pickup current	0.5 to 10 A [1)] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A [1)]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1)]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors *(ANSI 48)*	
Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1)] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1)] (in steps of 0.01)
Permissible starting time $T_{STARTUP}$	1 to 180 s (in steps of 0.1 s)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$ $I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1)]
Delay time	5 % or 30 ms

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Restart inhibit for motors (ANSI 66)	
Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A[1] (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	3 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state

Undercurrent monitoring (ANSI 37)	
Signal from the operational measured values	Predefined with programmable logic

Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

1) At I_{nom} = 1 A, all limits divided by 5.

Undervoltage protection (ANSI 27)	
Operating modes/measuring quantities	
3-phase	Positive-sequence component or smallest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$	
3-phase, phase-earth connection	10 to 210 V (in steps of 1 V)
3-phase, phase-phase connection	10 to 120 V (in steps of 1 V)
1-phase connection	10 to 120 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A[1] (in steps of 0.01 A)
Dropout threshold $r \cdot V<(<)$	Max. 130 V for phase-phase voltages Max. 225 V phase-earth voltages
Times	
Pickup times $V<$, $V<<$, $V_1<$, $V_1<<$	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Overvoltage protection (ANSI 59)	
Operating modes/measuring quantities	
3-phase	Negative-sequence component or largest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$	
3-phase, phase-earth connection, largest phase-phase voltage	40 to 260 V (in steps of 1 V)
3-phase, phase-phase connection, largest phase-phase voltage	40 to 150 V (in steps of 1 V)
3-phase, negative-sequence voltage	2 to 150 V (in steps of 1 V)
1-phase connection	40 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Pickup times $V_2>$, $V_2>>$	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Technical data

Frequency protection (ANSI 81)	
Number of frequency elements	4
Setting ranges	
Pickup thresholds for f_{nom} = 50 Hz	45.5 to 54.5 Hz (in steps of 0.01 Hz)
Pickup thresholds for f_{nom} = 60 Hz	55.5 to 64.5 Hz (in steps of 0.01 Hz)
Delay times	0 to 100 s or ∞ (in steps of 0.01 s)
Undervoltage blocking, with positive-sequence voltage V_1	10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 150 ms
Dropout times	Approx. 150 ms
Dropout	
Δf = pickup value - dropout value	Approx. 20 mHz
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	10 mHz
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms
Fault locator (ANSI 21FL)	
Output of the fault distance	In Ω secondary, in km / mile of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km[1)] (in steps of 0.0001) 0.001 to 3 Ω/mile[1)] (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for 30 ° ≤ φK ≤ 90 ° and V_K/V_{nom} ≥ 0.1 and I_K/I_{nom} ≥ 1

1) At I_{nom} = 1 A, all limits multiplied with 5.

2) At rated frequency.

Additional functions	
Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range Tolerance[2)]	10 to 200 % I_{nom} 1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages $V_{L1\text{-}E}$, $V_{L2\text{-}E}$, $V_{L3\text{-}E}$ Phase-to-phase voltages $V_{L1\text{-}L2}$, $V_{L2\text{-}L3}$, $V_{L3\text{-}L1}$, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range Tolerance[2)]	10 to 120 % V_{nom} 1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range Tolerance[2)]	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %
P, active Power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}
Range Tolerance[2)]	0 to 120 % S_{nom} 2 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert \cos\varphi \rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range Tolerance[2)]	0 to 120 % S_{nom} 2 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert \sin\varphi \rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
cos φ, power factor (p.f.)	Total and phase segregated
Range Tolerance[2)]	- 1 to + 1 3 % for $\lvert \cos\varphi \rvert$ ≥ 0.707
Frequency f	In Hz
Range Tolerance[2)]	f_{nom} ± 5 Hz 20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance[2)]	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\,Trip}$	In %
Range Tolerance[2)]	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\,Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\,real}$, $I_{EE\,reactive}$	In A (kA) primary and in mA secondary
Range Tolerance[2)]	0 mA to 1600 mA 2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"

5

Technical data

Long-term averages	
Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages of currents of real power of reactive power of apparent power	 I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA) P_{dmd} in W (kW, MW) Q_{dmd} in VAr (kVAr, MVAr) S_{dmd} in VAr (kVAr, MVAr)
Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	V_{L1-E}, V_{L2-E}, V_{L3-E} V_1 (positive-sequence component) V_{L1-L2}, V_{L2-L3}, V_{L3-L1}
Min./Max. values for power	S, P, Q, cos φ, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}
Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for $I>I_{balance\ limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for $V>V_{lim}$
Current sum	$\lvert i_{L1} + i_{L2} + i_{L3} + k_{iE} \cdot i_E \rvert$ > limit value, with $k_{iE} = \frac{I_{earth}\ \text{CT PRIM} / I_{earth}\ \text{CT SEC}}{\text{CT PRIM} / \text{CT SEC}}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	

Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 5 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 sam/cyc) 1 sample/1.04 ms (16 sam/cyc)
Energy/power	
Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance[1)]	≤ 5 % for $I > 0.5\ I_{nom}$, $V > 0.5\ V_{nom}$ and $\lvert \cos\varphi \rvert$ (p.f.) ≥ 0.707
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits
Circuit-breaker wear	
Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life)
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})
Trip circuit monitoring	
With one or two binary inputs	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker / switching device test, creation of a test measurement report	

1) At rated frequency.

Technical data

Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, assignment of a function key
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

5

Selection and ordering data

Description	Order No.
7SJ62 multifunction protection relay	7SJ62☐☐ – ☐☐☐☐☐ – ☐☐☐☐
Housing, binary inputs (BI) and outputs (BO)	
Housing 1/3 19"; 8 BI, 8 BO, 1 live status contact	1
Housing 1/3 19"; 11 BI, 6 BO, 1 live status contact	2
Measuring inputs (3 x V, 4 x I)	
I_{ph} = 1 A[1)], I_e = 1 A[1)] (min. = 0.05 A) Position 15 only with A, C, E, G	1
I_{ph} = 1 A[1)], I_e = sensitive (min. = 0.001 A) Position 15 only with B, D, F, H	2
I_{ph} = 5 A[1)], I_e = 5 A[1)] (min. = 0.25 A) Position 15 only with A, C, E, G	5
I_{ph} = 5 A[1)], I_e = sensitive (min. = 0.001 A) Position 15 only with B, D, F, H	6
I_{ph} = 5 A[1)], I_e = 1 A[1)] (min. = 0.05 A) Position 15 only with A, C, E, G	7
Rated auxiliary voltage (power supply, indication voltage)	
24 to 48 V DC, threshold binary input 19 DC[3)]	2
60 to 125 V DC[2)], threshold binary input 19 DC[3)]	4
110 to 250 V DC[2)], 115 to 230 V[4)] AC, threshold binary input 88 V DC[3)]	5
Unit version	
For panel surface mounting, two-tier terminal top/bottom	B
For panel flush mounting, plug-in terminal, (2/3 pin connector)	D
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	E
Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German, selectable	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	B
Region US, 60 Hz, ANSI, language: English (US), selectable	C
Region FR, 50/60 Hz, IEC/ANSI, language: French, selectable	D
Region World, 50/60 Hz, IEC/ANSI, language: Spanish, selectable	E
System interface (Port B): Refer to page 5/112	
No system interface	0
Protocols see page 5/112	
Service interface (Port C)	
No interface at rear side	0
DIGSI 4/modem, electrical RS232	1
DIGSI 4/modem/RTD-box[5)], electrical RS485	2
DIGSI 4/modem/RTD-box[5)6)], optical 820 nm wave length, ST connector	3
Measuring/fault recording	
Fault recording	1
Slave pointer, mean values, min/max values, fault recording	3

see next page

1) Rated current can be selected by means of jumpers.
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
3) The binary input thresholds can be selected per binary input by means of jumpers.
4) 230 V AC, starting from device version …/EE.
5) Temperature monitoring box 7XV5662-☐AD10, refer to "Accessories".
6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0☐A00 is required.

5

Selection and ordering data

Description						Order No.
7SJ62 multifunction protection relay						*7SJ62□□ – □□□□□ – □□□□*
Designation				ANSI No.	Description	
Basic version				 50/51 50N/51N 50N/51N 49 46 37 47 59N/64 50BF 74TC 86	Control Time-overcurrent protection $I>$, $I>>$, I_p, reverse interlocking Earth-fault protection $I_E>$, $I_E>>$, I_{Ep} Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1) Overload protection (with 2 time constants) Phase balance current protection (negative-sequence protection) Undercurrent monitoring Phase sequence Displacement voltage Breaker failure protection Trip circuit supervision 4 setting groups, cold-load pickup Inrush blocking Lockout	
■			*V*, *f*	27/59 81 O/U	Under-/overvoltage Under-/overfrequency	*F E*
■		IEF	*V*, *f*	27/59 81 O/U	Under-/overvoltage Under-/overfrequency Intermittent earth fault	*P E*
■	Dir			67/67N	Direction determination for overcurrent, phases and earth	*F C*
■	Dir		*V*, *f*	67/67N 27/59 81O/U	Direction determination for overcurrent, phases and earth Under-/overvoltage Under-/overfrequency	*F G*
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth Intermittent earth fault	*P C*
Directional earth-fault detection ■	Dir			67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault	*F D* 2)
Directional earth-fault detection ■	Dir	IEF		67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Intermittent earth fault	*P D* 2)
Directional earth-fault detection ■				67Ns 87N	Directional sensitive earth-fault detection, High-impedance restricted earth fault	*F B* 2)
Directional earth-fault detection ■	Motor		*V*, *f*	67Ns 87N 48/14 66/86 27/59 81O/U	Directional sensitive earth-fault detection, High-impedance restricted earth fault Starting time supervision, locked rotor Restart inhibit Under-/overvoltage Under-/overfrequency	*H F* 2)
Directional earth-fault detection ■	Motor Dir		*V*, *f*	67/67N 67Ns 87N 48/14 66/86 27/59 81O/U	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Starting time supervision, locked rotor Restart inhibit Under-/overvoltage Under-/overfrequency	*H H* 2)

■ Basic version included

V, *f* = Voltage, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Continued on next page

Selection and ordering data

Description	Order No.	Order code
7SJ62 multifunction protection relay	*7SJ62□□ – □□□□□ – □□□□–□□□□*	

Designation			ANSI No.	Description	Order code
Basic version				Control	
			50/51	Time-overcurrent protection $I>$, $I>>$, I_p, reverse interlocking	
			50N/51N	Earth-fault protection $I_E>$, $I_E>>$, I_{Ep}	
			50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} [1)]	
			49	Overload protection (with 2 time constants)	
			46	Phase balance current protection (negative-sequence protection)	
			37	Undercurrent monitoring	
			47	Phase sequence	
			59N/64	Displacement voltage	
			50BF	Breaker failure protection	
			74TC	Trip circuit supervision	
				4 setting groups, cold-load pickup	
				Inrush blocking	
			86	Lockout	
Directional earth-fault detection ■	Motor Dir	V, f	67/67N	Direction determination for overcurrent, phases and earth	
			67Ns	Directional sensitive earth-fault detection	
			87N	High-impedance restricted earth fault	
			48/14	Starting time supervision, locked rotor	
			66/86	Restart inhibit	
			27/59	Under-/overvoltage	
			81O/U	Under-/overfrequency	*R H* [2)]
■	Motor Dir	V, f	67/67N	Direction determination for overcurrent, phases and earth	
			48/14	Starting time supervision, locked rotor	
			66/86	Reclosing lockout	
			27/59	Under/overvoltage	
			81 O/U	Under/overfrequency	*H G*
ARC, fault locator				Without	*0*
			79	With auto-reclosure	*1*
			21 FL	With fault locator	*2*
			79, 21 FL	With auto-reclosure, with fault locator	*3*
ATEX100 Certification For protection of explosion-protected motors (increased-safety type of protection "e")					*Z X 9 9*

■ Basic version included

V, f = Voltage, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Order number for system port B

Description	Order No.	Order code
7SJ62 multifunction protection relay	*7SJ62□□ – □□□□□ – □□□□–□□□*	
System interface (on rear of unit, Port B)		
No system interface	*0*	
IEC 60870-5-103 protocol, RS232	*1*	
IEC 60870-5-103 protocol, RS485	*2*	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	*3*	
PROFIBUS-FMS Slave, RS485	*4*	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector 1)	*5*	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector 1)	*6*	
PROFIBUS-DP Slave, RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector 1)	*9*	*L 0 B*
MODBUS, RS485	*9*	*L 0 D*
MODBUS, 820 nm wavelength, ST connector 2)	*9*	*L 0 E*
DNP 3.0, RS485	*9*	*L 0 G*
DNP 3.0, 820 nm wavelength, ST connector 2)	*9*	*L 0 H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector (EN 100)2)	*9*	*L 0 S*

1) Not with position 9 = “*B*”; if 9 = “*B*”, please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = “*B*”.
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = “*B*”.
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00)

2) Not available with position 9 = “*B*”

Sample order

Position		Order No. + Order code
		7SJ6225-5EC91-3FC1+L0G
6	I/O’s: 11 BI/6 BO, 1 live status contact	*2*
7	Current transformer: 5 A	*5*
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	*5*
9	Unit version: Flush-mounting housing, screw-type terminals	*E*
10	Region: US, English language (US); 60 Hz, ANSI	*C*
11	Communication: System interface: DNP 3.0, RS485	*9* *L0G*
12	Communication: DIGSI 4, electric RS232	*1*
13	Measuring/fault recording: Extended measuring and fault records	*3*
14/15	Protection function package: Basic version plus directional TOC	*FC*
16	With auto-reclosure	*1*

Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		7XS5460-0AA00
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		7XS5410-0AA00
Temperature monitoring box		
24 to 60 V AC/DC		7XV5662-2AD10
90 to 240 V AC/DC		7XV5662-5AD10
Varistor/Voltage arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		C53207-A401-D76-1
240 Vrms; 600 A; 1S/S 1088		C53207-A401-D77-1
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		7XV5100-4
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		7XV5103-7AA05
- length 25 m /82 ft		7XV5103-7AA25
- length 50 m /164 ft		7XV5103-7AA50
Manual for 7SJ62/63/64,		
English		C53000-G1140-C147-6
French		C53000-G1177-C147-2
Spanish		C53000-G1178-C147-2
Catalog SIP 3.1 Spanish		E50001-K4403-A111-A1-7800

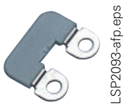
5

Accessories

Mounting rail

2-pin connector

3-pin connector



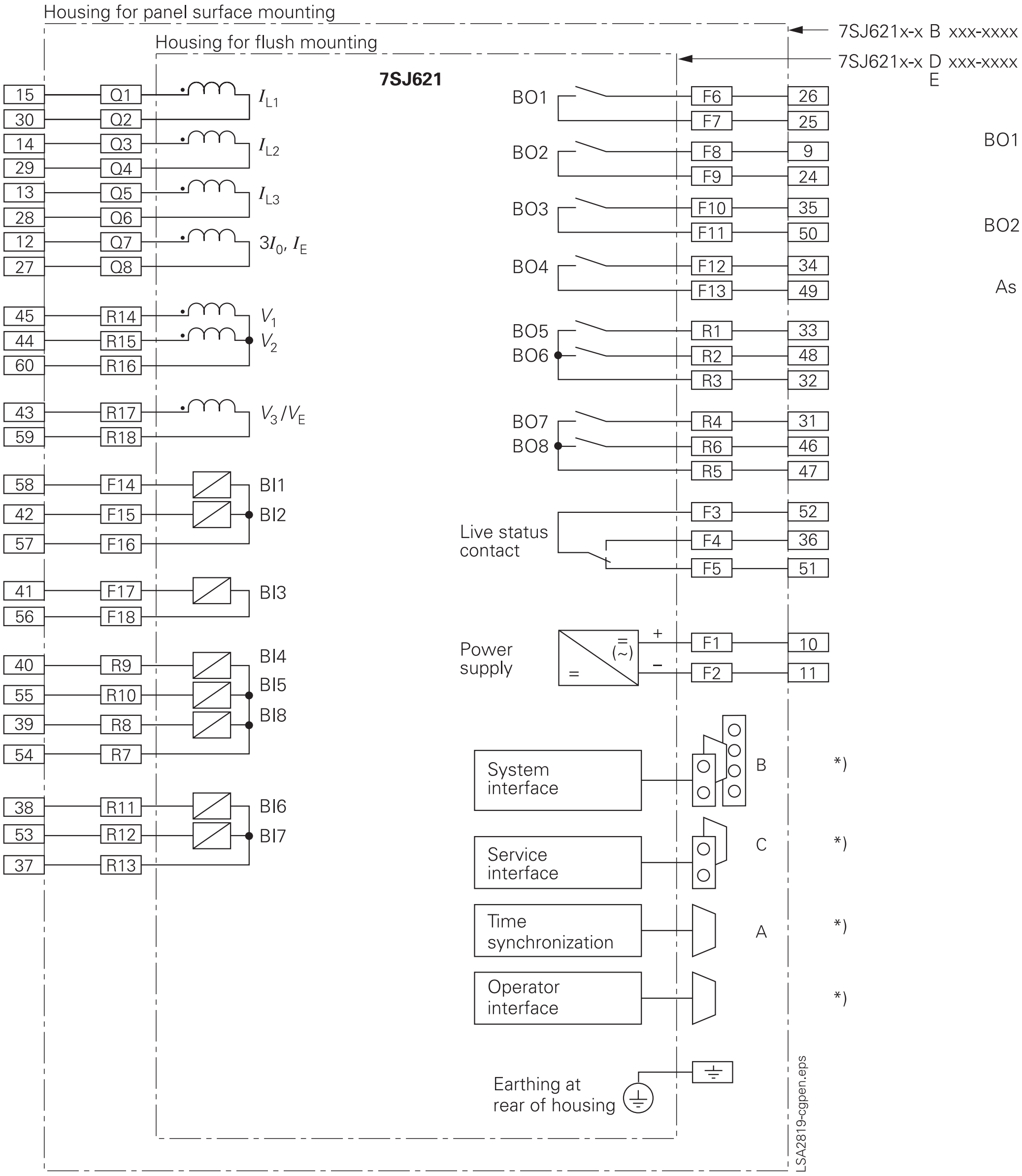
Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin	C73334-A1-C35-1	1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram



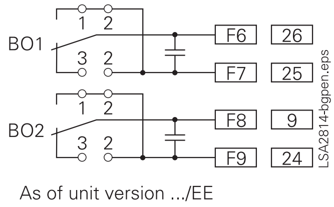
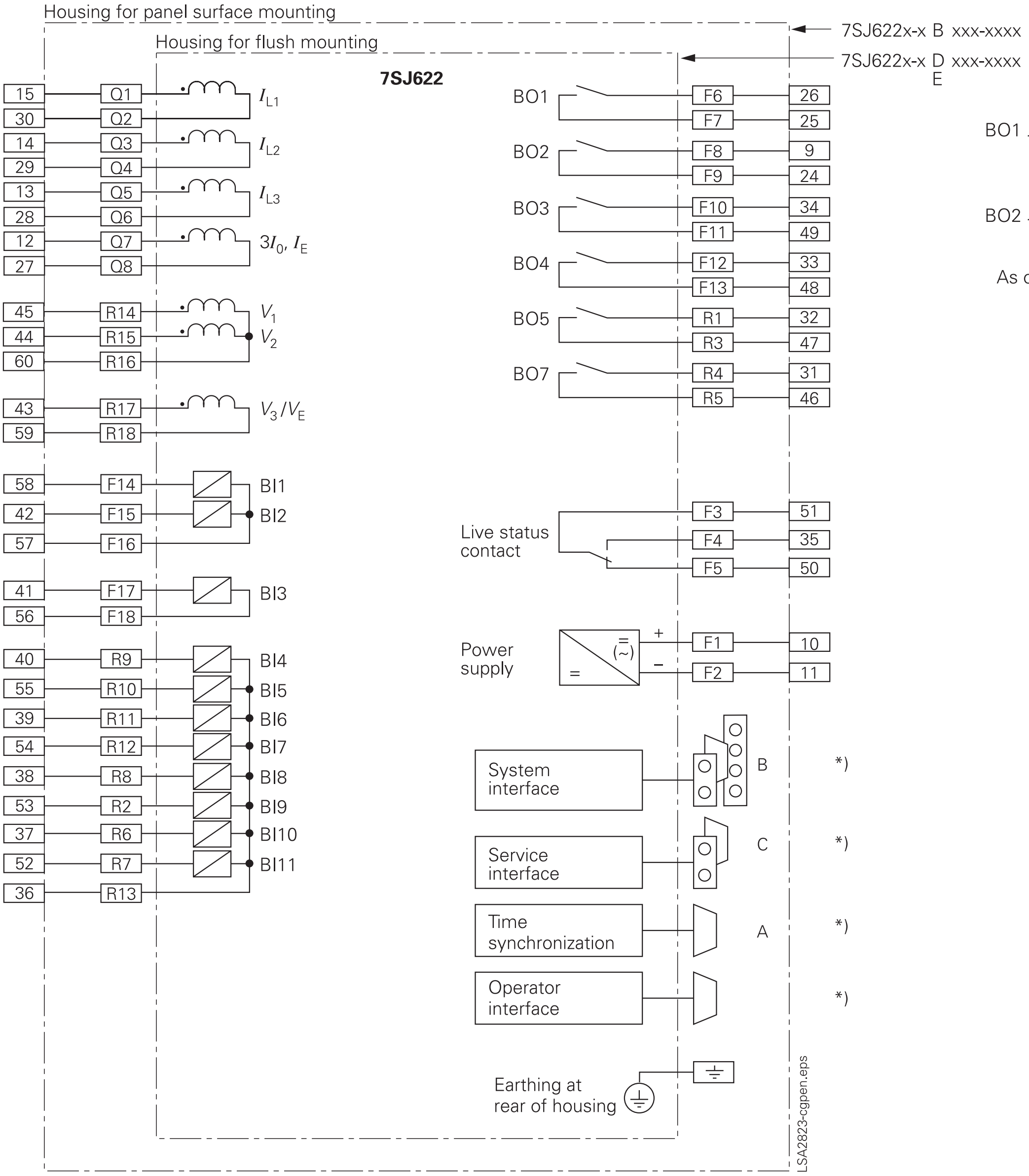


Fig. 5/102 7SJ621 connection diagram

*) For pinout of communication ports see part 16 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siprotec.com).

Connection diagram



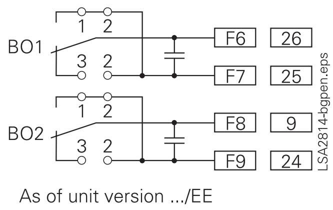


Fig. 5/103 7SJ622 connection diagram

*) For pinout of communication ports see part 16 of this catalog.
For the allocation of the terminals of the panel surface mounting version refer to the manual (http://www.siprotec.com).

SIPROTEC 4 7SJ63
Multifunction Protection Relay

LSP2316-afpen.tif

Fig. 5/104
SIPROTEC 4 7SJ63 multifunction protection relay

Description

The SIPROTEC 4 7SJ63 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance earthed, unearthed, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. Regarding the time-overcurrent/directional time-overcurrent protection the characteristics can be either definite time, inverse time or user-defined.

The SIPROTEC 4 7SJ63 is equipped with motor protection applicable for asynchronous machines of all sizes. Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). The user is able to generate user-defined messages as well.

Function overview

Protection functions

- Time-overcurrent protection (definite-time/inverse-time/user-def.)
- Directional time-overcurrent protection (definite-time/inverse-time/user-def.)
- Sensitive dir./non-dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Flexible number of switching devices
- Position of switching elements is shown on the graphic display
- Local/remote switching via key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- Extended user-defined logic with CFC (e.g. interlocking)

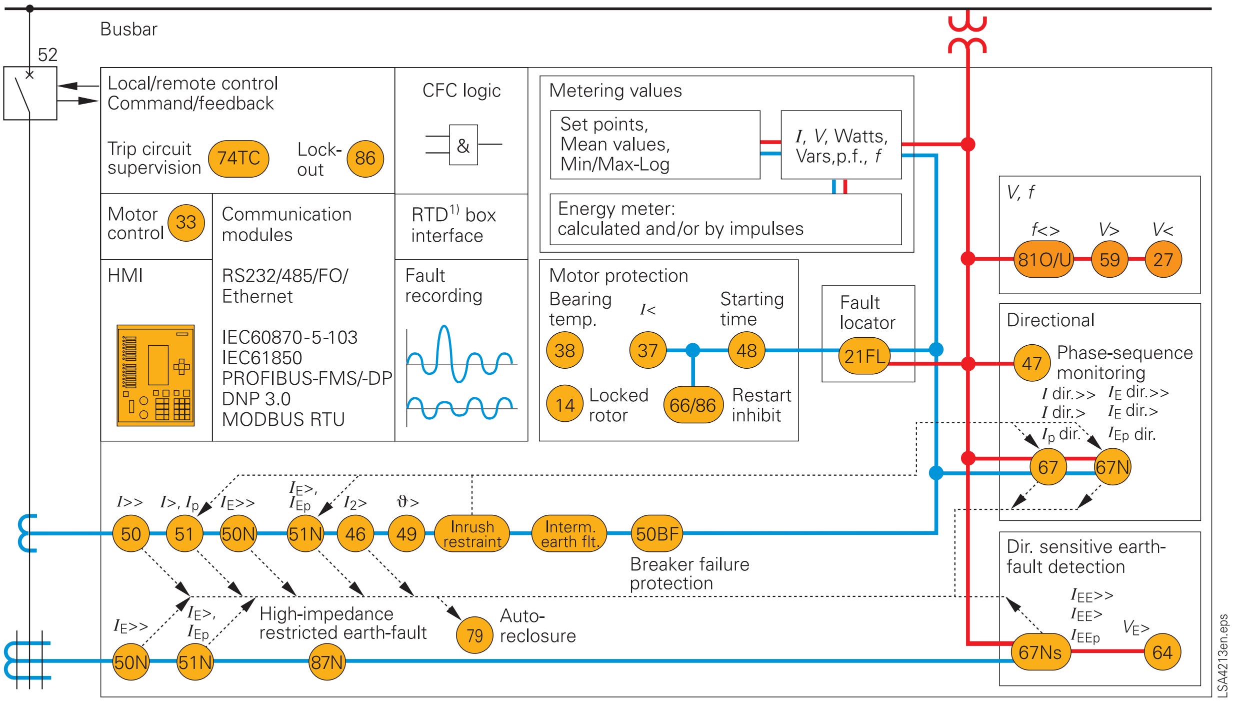
Monitoring functions

- Operational measured values V, I, f,...
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records

Communication interfaces

- System interface
  – IEC 60870-5-103, IEC 61850
  – PROFIBUS-FMS /-DP
  – DNP 3.0 / MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG-B/DCF77

Application



[1)] RTD = resistance temperature detector

Fig. 5/105 Function diagram

The SIPROTEC 4 7SJ63 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ63 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow the user to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. The user can also generate user-defined messages.

Line protection

The 7SJ63 units can be used for line protection of high and medium-voltage networks with earthed (grounded), low-resistance earthed, isolated or compensated neutral point.

Motor protection

When protecting motors, the 7SJ63 relays are suitable for asynchronous machines of all sizes.

Transformer protection

The 7SJ63 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted earth-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

The relays can be used universally for backup protection.

Metering values

Extensive measured values, limit values and metering values permit improved systems management.

Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\ dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\ dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral), Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	$V_E/V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79		Auto-reclosure
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase seq.	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device (RTD-box) e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Undervoltage/overvoltage protection
81O/U	$f>$, $f<$	Overfrequency/underfrequency protection
21FL		Fault locator

Construction

Connection techniques and housing with many advantages

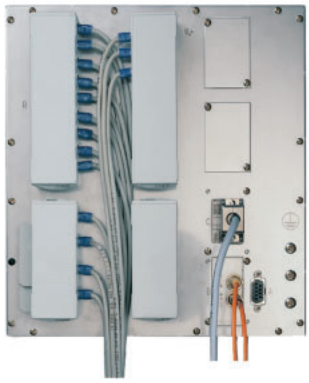
1/2 and 1/1-rack sizes

These are the available housing widths of the 7SJ63 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.

It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/108), or without operator panel, in order to allow optimum operation for all types of applications.

LSP2174-afp.tif

Fig. 5/106
Flush-mounting housing with screw-type terminals



LSP2166-afp.tif

Fig. 5/107
Rear view of flush-mounting housing with covered connection terminals and wirings

LSP2196-afp.eps

Fig. 5/108
Housing with plug-in terminals and detached operator panel

LSP2219-afpen.eps

LSP2237-afp.tif

Fig. 5/110
Communication interfaces in a sloped case in a surface-mounting housing

Fig. 5/109
Surface-mounting housing with screw-type terminals

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Two definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set within a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.

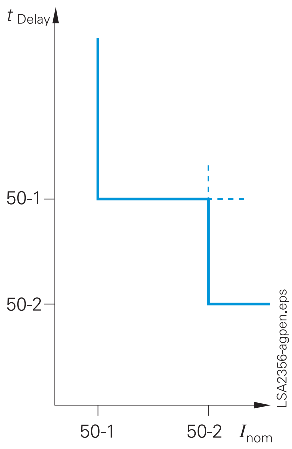


Fig. 5/111
Definite-time overcurrent protection

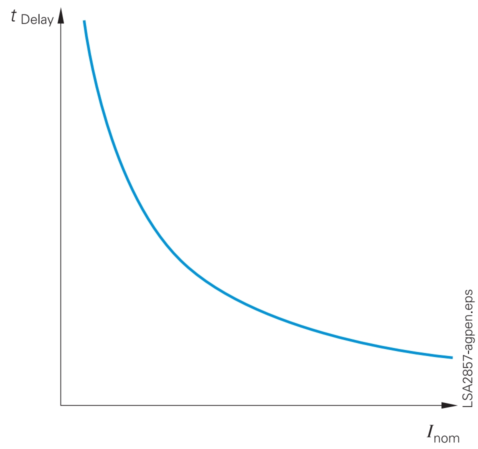


Fig. 5/112
Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and earth units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and non-directional time-overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

5

Protection functions

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristic is offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directio- nality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable). Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated time-overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0. For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions,

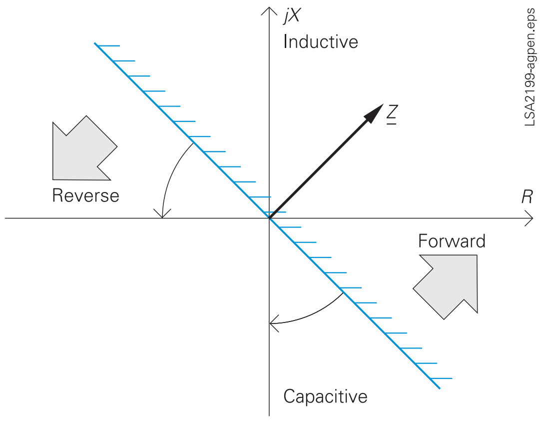


Fig. 5/113
Directional characteristic of the directional time-overcurrent protection

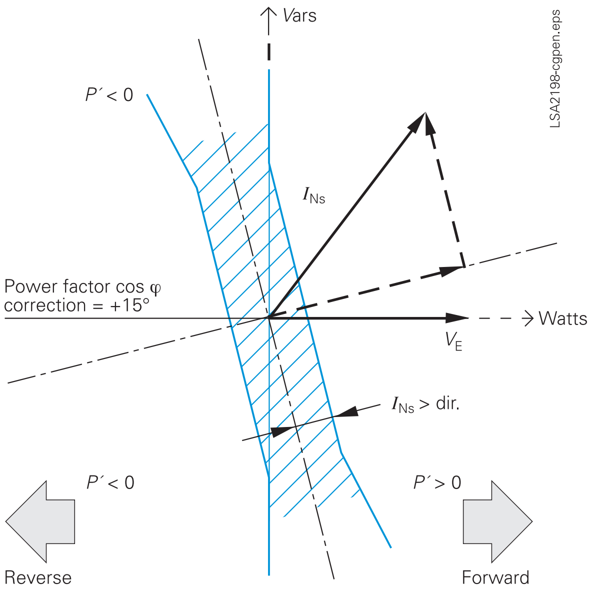


Fig. 5/114
Directional determination using cosine measurements for compensated networks

e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of earth-fault direction detection can be implemented: tripping or “signalling only mode”.

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode as an additional short-circuit protection.

Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-earth faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

High-impedance restricted earth-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting earth faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an earthed network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/115). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}. The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value.
If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted earth-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Auto-reclosure (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR

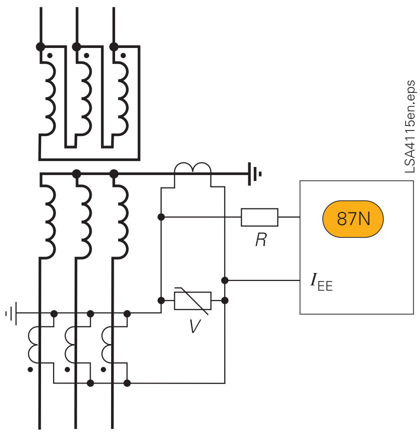


Fig. 5/115 High-impedance restricted earth-fault protection

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator) a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD- box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, earth short-circuit and phase-balance current protection.

5

Protection functions

Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/116).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/149).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\mathrm{MOTOR\,START}}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\mathrm{MOTOR\,START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current

1) The 45 to 55, 55 to 65 Hz range is available for f_N = 50/60 Hz.

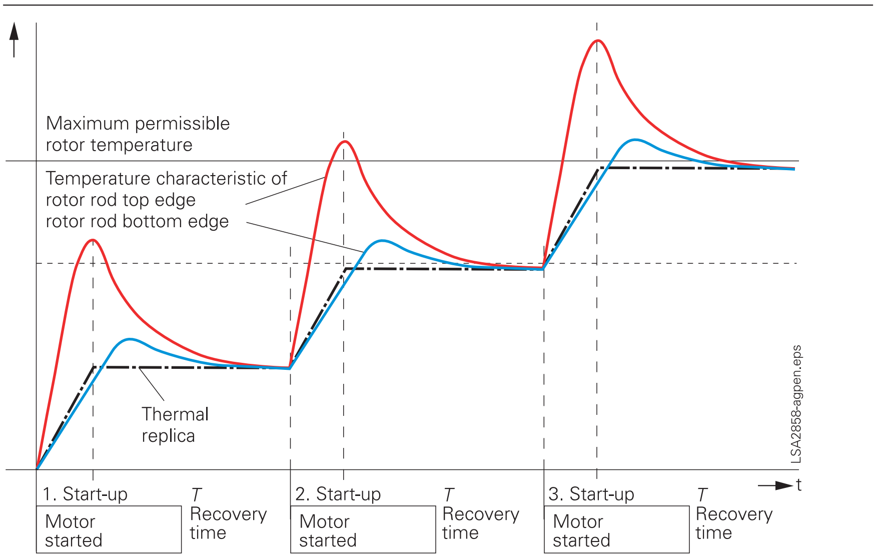


Fig. 5/116

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase voltage (default) or with the negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with the positive phase-sequence system voltage (default) or with the phase-to-phase voltages, and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Protection functions/Functions

Fault locator (ANSI 21FL)

The fault locator specifies the distance to a fault location in kilometers or miles or the reactance of a second fault operation.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/117) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

Customized functions (ANSI 32, 51V, 55, etc.)

Additional functions, which are not time critical, can be implemented via the CFC using measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

1) The 45 to 55, 55 to 65 Hz range is available for f_N= 50/60 Hz

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ63 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

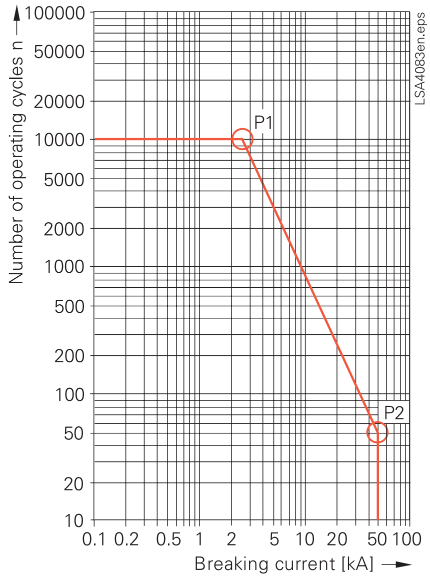


Fig. 5/117 CB switching cycle diagram

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).
If a source is set to "LOCAL", only local switching operations are possible. The following sequence of switching authority is laid down: "LOCAL"; DIGSI PC program, "REMOTE".

Key-operated switch

7SJ63 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Functions

Motor control

The SIPROTEC 4 7SJ63 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and earthing switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

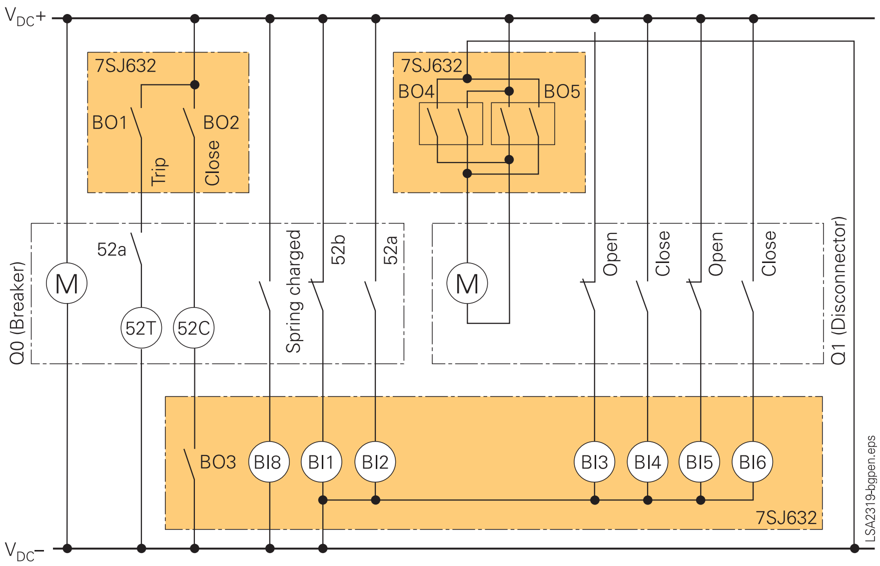


Fig. 5/118
Typical wiring for 7SJ632 motor direct control (simplified representation without fuses)
Binary output BO4 and BO5 are interlocked so that only one set of contacts are closed at a time.

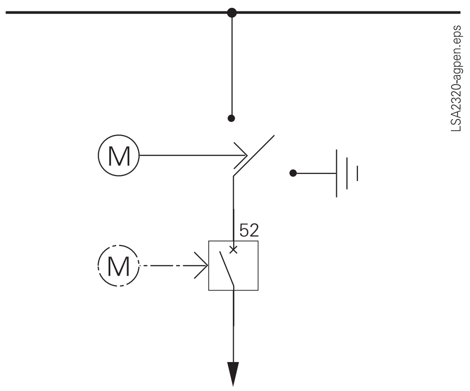


Fig. 5/119 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

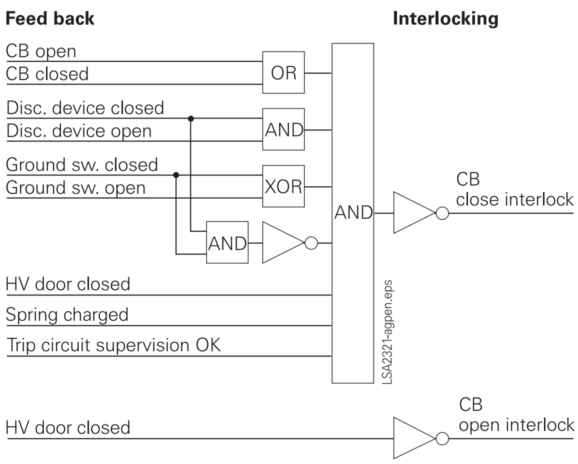


Fig. 5/120 Example: Circuit-breaker interlocking

Functions

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}
- Symmetrical components
  I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S
  (P, Q: total and phase-selective)
- Power factor (cos φ)
  (total and phase-selective)
- Frequency
- Energy ± kWh, ± kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
  Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Measuring transducers

- Characteristic with knee
  For measuring transducers it sometimes makes sense to extend a small range of the input value, e.g. for the frequency that is only relevant in the range 45 to 55, 55 to 65 Hz. This can be achieved by using a knee characteristic.
- Live-zero monitoring
  4 - 20 mA circuits are monitored for open-circuit detection.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g. for current, voltage, frequency measuring transducer ...) or additional control components are necessary.

Fig. 5/121
NX PLUS panel (gas-insulated)

5

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.
The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. On all units, it can be an electrical RS232/RS485 or an optical interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.

1) For units in panel surface-mounting housings please refer to note on page 5/148.

System interface protocols (retrofittable)

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized communication system (EN 50170) for efficient performance of communication tasks in the bay area. SIPROTEC 4 units use a profile specially optimized for protection and control requirements. DIGSI can also work on the basis of PROFIBUS-FMS. The units are linked to a SICAM automation system.

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

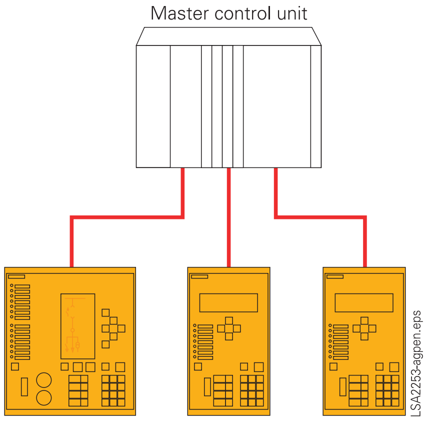


Fig. 5/122
IEC 60870-5-103: Radial fiber-optic connection

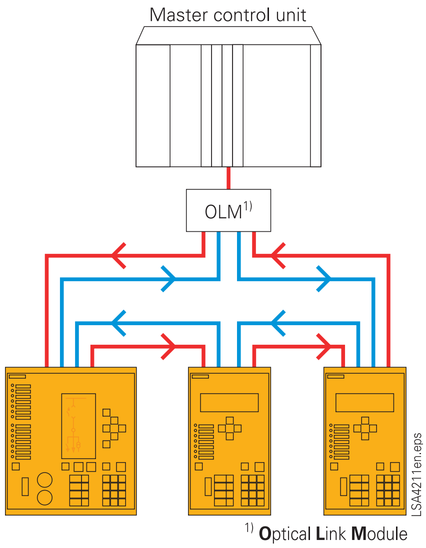


Fig. 5/123
PROFIBUS: Fiber-optic double ring circuit

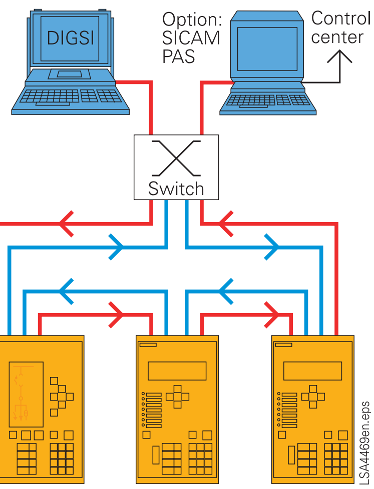


Fig. 5/124
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

Communication

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/122).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/124).

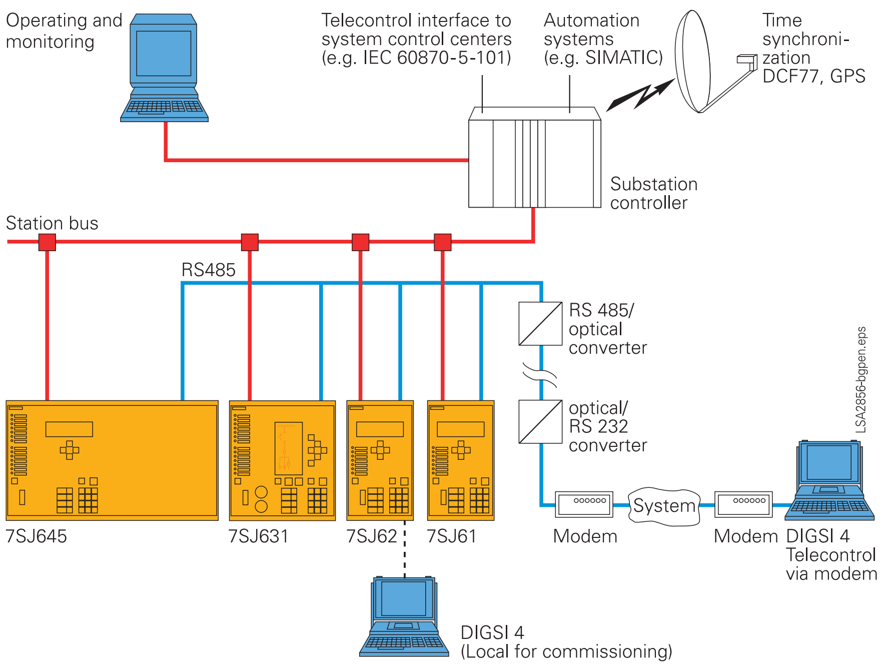


Fig. 5/125
System solution/communication

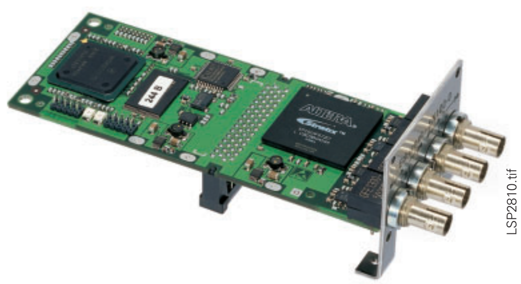


Fig. 5/126
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Typical connections

■ Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

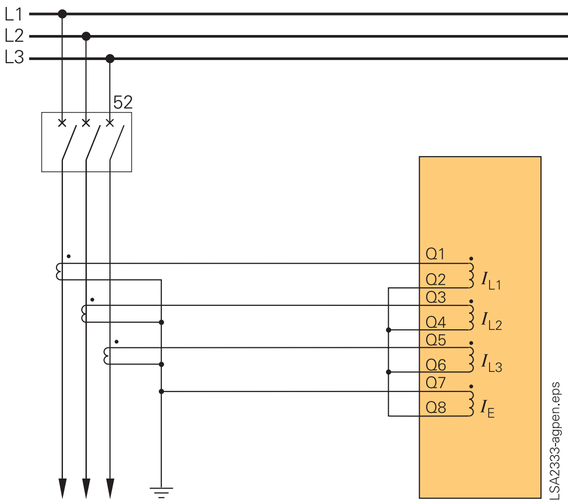


Fig. 5/127
Residual current circuit without directional element

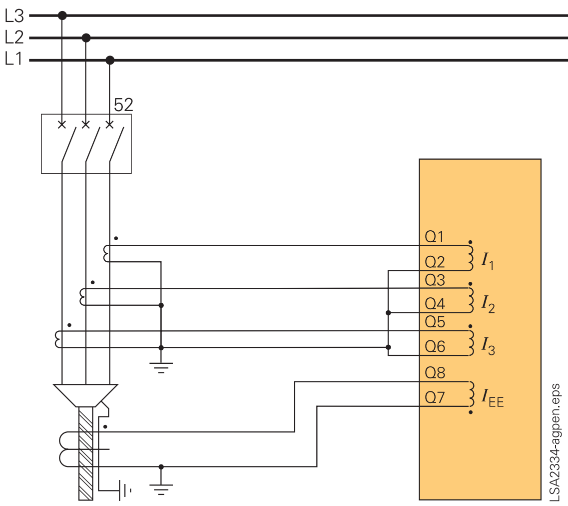


Fig. 5/128
Sensitive earth current detection without directional element

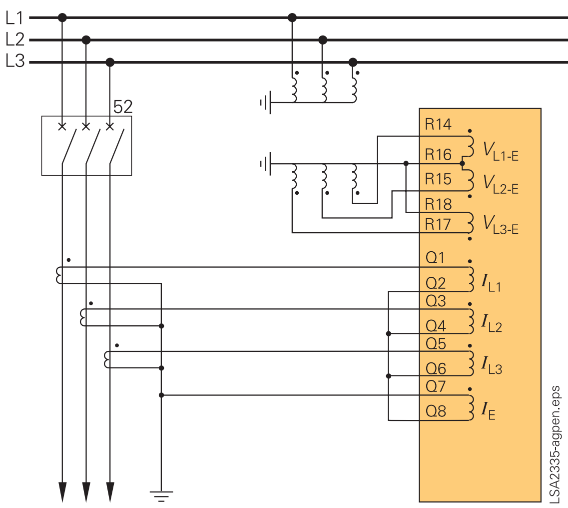


Fig. 5/129
Residual current circuit with directional element

Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-balance neutral current transformer for the earth current. This connection maintains maximum precision for directional earth-fault detection and must be used in compensated networks.
Figure 5/130 shows sensitive directional earth-fault detection.

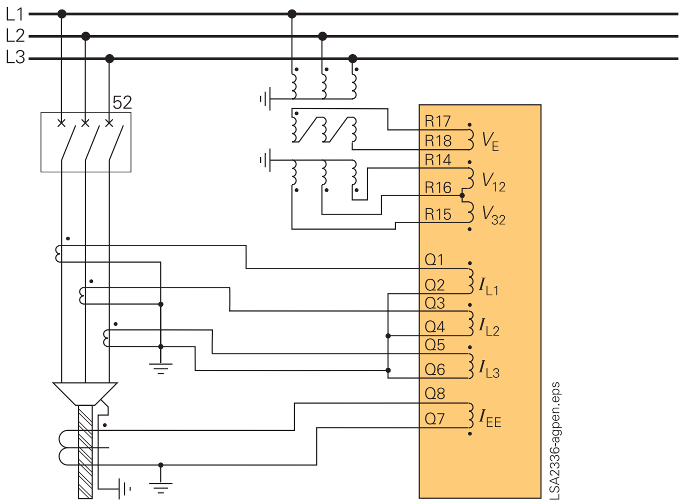


Fig. 5/130
Sensitive directional earth-fault detection with directional element for phases

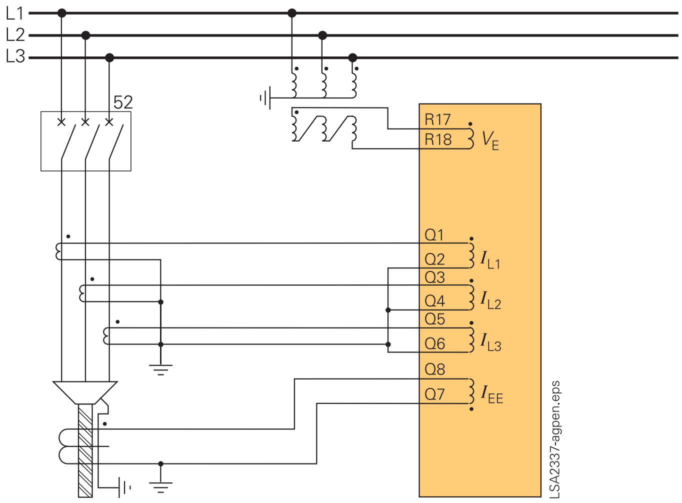


Fig. 5/131
Sensitive directional earth-fault detection

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

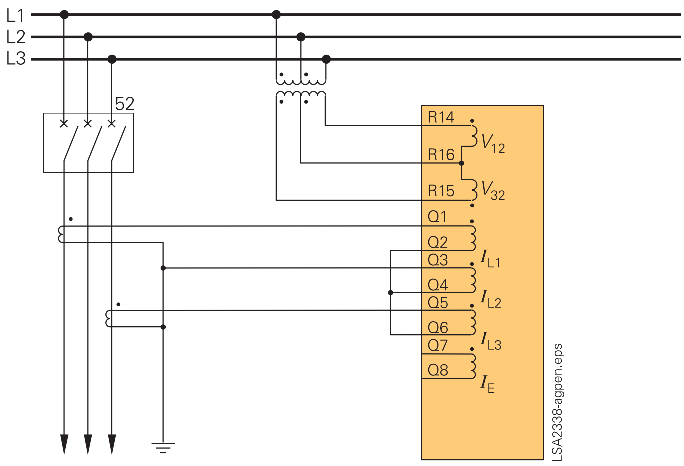


Fig. 5/132
Isolated-neutral or compensated networks

Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current > 0.05 I_N on secondary side, other-wise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

5

■ Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Fig. 5/133, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of a network fault.

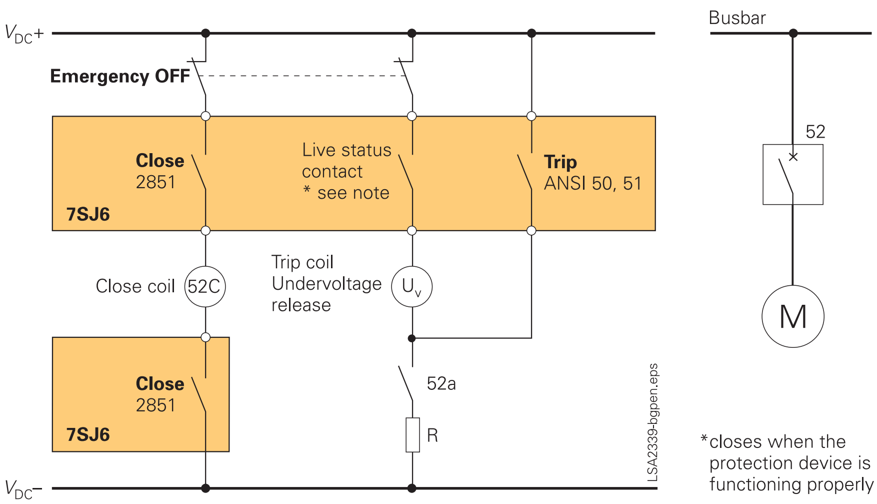


Fig. 5/133 Undervoltage release with make contact (50, 51)

Typical applications

In Fig. 5/134 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

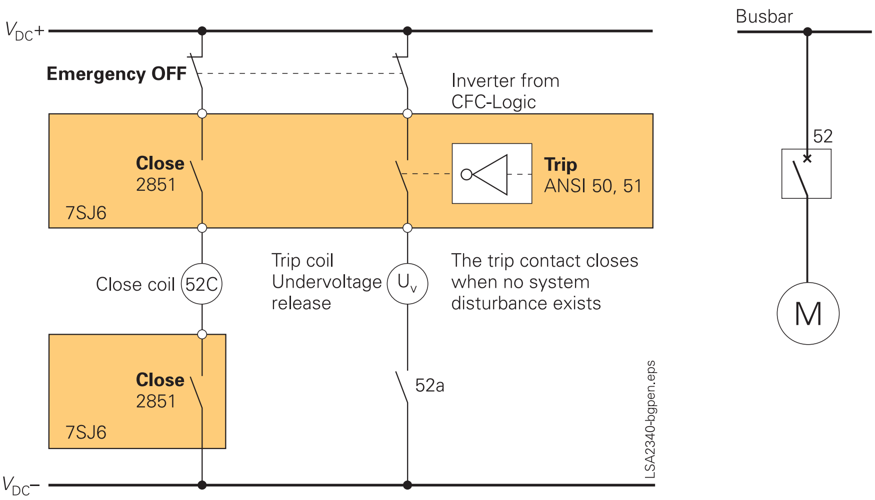
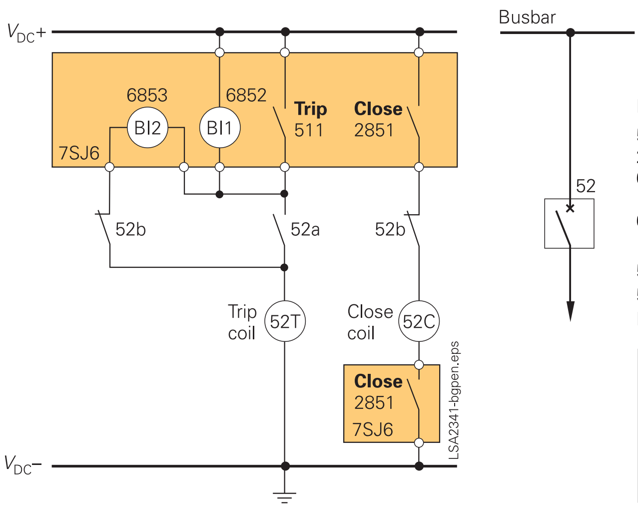


Fig. 5/134 Undervoltage release with locking contact (trip signal 50 is inverted)



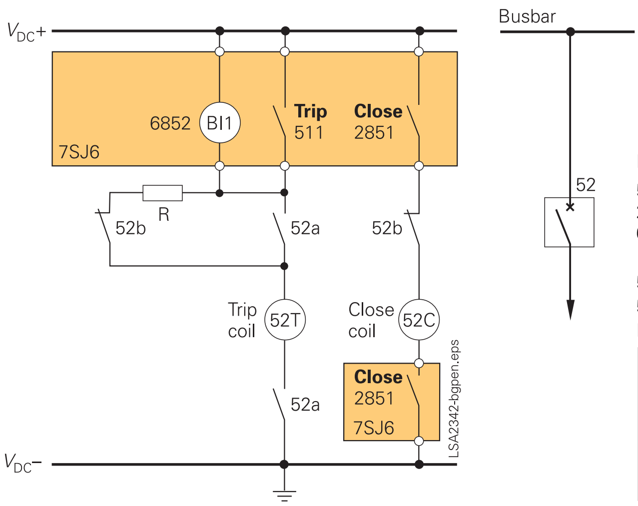
Protection indications

511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay
6853* Trip circuit supervision: CB aux

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/135 Trip circuit supervision with 2 binary inputs



Protection indications

511* General trip
2851* CB close command
6852* Trip circuit supervision: Trip relay

52a open, when CB is open
52b open, when CB is closed
BI Binary input

TRIP contact	Breaker	BI1
open	closed	H
open	open	H
closed	closed	L
closed	open	L

Fig. 5/136 Trip circuit supervision with 1 binary input

5

Technical data

General unit data

Measuring circuits

System frequency	50 / 60 Hz (settable)

Current transformer

Rated current I_{nom}	1 or 5 A (settable)
Option: sensitive earth-fault CT	I_{EE} < 1.6 A
Power consumption	
at I_{nom} = 1 A	Approx. 0.05 VA per phase
at I_{nom} = 5 A	Approx. 0.3 VA per phase
for sensitive earth-fault CT at 1 A	Approx. 0.05 VA
Overload capability	
Thermal (effective)	100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous
Dynamic (impulse current)	250 x I_{nom} (half cycle)
Overload capability if equipped with sensitive earth-fault CT	
Thermal (effective)	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (impulse current)	750 A (half cycle)

Voltage transformer

Rated voltage V_{nom}	100 V to 225 V
Power consumption at V_{nom} = 100 V	< 0.3 VA per phase
Overload capability in voltage path (phase-neutral voltage)	
Thermal (effective)	230 V continuous

Measuring transducer inputs

Type	7SJ633	7SJ636
Number	2	2
Input current	DC 0 - 20 mA	
Input resistance	10 Ω	
Power consumption	5.8 mW at 24 mA	

Auxiliary voltage *(via integrated converter)*

Rated auxiliary voltage V_{aux}	DC	24/48 V	60/125 V	110/250 V
Permissible tolerance	DC	19 - 58 V	48 - 150 V	88 - 300 V
Ripple voltage, peak-to-peak		≤ 12 % of rated auxiliary voltage		
Power consumption		7SJ631	7SJ632 7SJ633	7SJ635 7SJ636
Quiescent	Approx.	4 W	5.5 W	7 W
Energized	Approx.	10 W	16 W	20 W
Backup time during loss/short-circuit of auxiliary direct voltage		≥ 50 ms at V > 110 V DC ≥ 20 ms at V > 24 V DC		
Rated auxiliary voltage V_{aux}	AC	115 V	230 V	
Permissible tolerance	AC	92 - 132 V	184 - 265 V	
Power consumption		7SJ631	7SJ632 7SJ633	7SJ635 7SJ636
Quiescent	Approx.	3 W	5 W	7 W
Energized	Approx.	12 W	18 W	23 W
Backup time during loss/short-circuit of auxiliary alternating voltage		≥ 200 ms		

Binary inputs/indication inputs

Type	7SJ631	7SJ632	7SJ633	7SJ635	7SJ636
Number (marshallable)	11	24	20	37	33
Voltage range	24 - 250 V DC				
Pickup threshold modifiable by plug-in jumpers					
Pickup threshold DC	19 V DC		88 V DC		
For rated control voltage DC	24/48/60/110/ 125 V DC		110/125/220/250 V DC		
Power consumption energized	0.9 mA (independent of operating voltage) for BI 1…6 / 8…19 / 25…36; 1.8 mA for BI 7 / 20…24 / 37				

Binary outputs/command outputs

Type	7SJ631	7SJ632	7SJ633	7SJ635	7SJ636
Command/indication relay	8	11	11	14	14
Contacts per command/ indication relay	1 NO / form A				
Live status contact	1 NO / NC (jumper) / form A / B				
Switching capacity Make	1000 W / VA				
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms				
Switching voltage	≤ 250 V DC				
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles				

Power relay *(for motor control)*

Type	7SJ631	7SJ632 7SJ633 7SJ636	7SJ635
Number	0	2 (4)	4 (8)
Number of contacts/relay		2 NO / form A	
Switching capacity Make	1000 W / VA at 48 V … 250 V / 500 W at 24 V		
Break	1000 W / VA at 48 V … 250 V / 500 W at 24 V		
Switching voltage	≤ 250 V DC		
Permissible current	5 A continuous, 30 A for 0.5 s		

Technical data

Electrical tests	
Specification	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
Insulation tests	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
***EMC tests for interference immunity;** type tests*	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
***EMC tests for interference emission;** type tests*	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
<u>During transportation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

5

Technical data

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design		
Housing	7XP20	
Dimensions	See dimension drawings, part 16 of this catalog	
Weight in kg	Housing width 1/2	Housing width 1/1
Surface-mounting housing	7.5	15
Flush-mounting housing	6.5	13
Housing for detached operator panel	8.0	15
Detached operator panel	2.5	2.5
Degree of protection acc. to EN 60529		
Surface-mounting housing	IP 51	
Flush-mounting housing	Front: IP 51, rear: IP 20;	
Operator safety	IP 2x with cover	

Serial interfaces	
Operating interface *(front of unit)*	
Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	min. 4800 baud, max. 115200 baud
Service/modem interface *(rear of unit)*	
Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Setting as supplied 38400 baud min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location “C”
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

System interface (rear of unit)	
IEC 60870-5-103 protocol	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Setting as supplied: 9600 baud, min. 9600 baud, max. 19200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location “B”
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
IEC 61850 protocol	
Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors Mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	Intergr. ST connector for FO connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles
PROFIBUS-FMS/DP	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud

Technical data

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth

Fiber optic

Connection fiber-optic cable	Integr. ST connector for FO connection,
For flush-mounting housing/ surface-mounting housing with detached operator panel	mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/148
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles

MODBUS RTU, ASCII, DNP 3.0

Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud

RS485

Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth

Fiber-optic

Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/148
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

1) At I_{nom} = 1 A, all limits divided by 5.

Functions

Definite-time overcurrent protection, directional/non-directional (ANSI 50, 50N, 67, 67N)

Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)	
Setting ranges		
Pickup phase elements I>, I>>	0.5 to 175 A or ∞[1] (in steps of 0.01 A)	
Pickup earth elements I_E>, I_E>>	0.25 to 175 A or ∞[1] (in steps of 0.01 A)	
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)	
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)	
Times		
Pickup times (without inrush restraint, with inrush restraint + 10 ms)		
	Non-directional	Directional
With twice the setting value	Approx. 30 ms	45 ms
With five times the setting value	Approx. 20 ms	40 ms
Dropout times	Approx. 40 ms	
Dropout ratio	Approx. 0.95 for I/I_{nom} ≥ 0.3	
Tolerances		
Pickup	2 % of setting value or 50 mA[1]	
Delay times T, T_{DO}	1 % or 10 ms	

Inverse-time overcurrent protection, directional/non-directional (ANSI 51, 51N, 67, 67N)

Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or ∞[1] (in steps of 0.01 A)
Pickup earth element I_{EP}	0.25 to 20 A or ∞[1] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for I_p/I_{nom} ≥ 0.3, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA[1]
Pickup time for 2 ≤ I/I_p ≤ 20	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for 0.05 ≤ I/I_p ≤ 0.9	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

5

Technical data

Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range Rotation of reference voltage $V_{ref,rot}$	$V_{ref,rot} \pm 86°$ - 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For earth faults	
Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range Rotation of reference voltage $V_{ref,rot}$	$V_{ref,rot} \pm 86°$ - 180° to 180° (in steps of 1°)
Direction sensitivity Zero-sequence quantities $3V_0$, $3I_0$	 $V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative -sequence quantities $3V_2$, $3I_2$	$3V_2 \approx 5$ V negative-sequence voltage; $3I_2 \approx 225$ mA negative-sequence current 1)
Tolerances (phase angle error under reference conditions) For phase and earth faults	 ± 3 ° electrical
Inrush blocking	
Influenced functions	Time-overcurrent elements, I>, I_E>, I_p, I_{Ep} (directional, non-directional)
Lower function limit	1.25 A 1)
Upper function limit (setting range)	1.5 to 125 A 1) (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF
Dynamic setting change	
Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

(Sensitive) earth-fault detection *(ANSI 64, 50 Ns, 51Ns, 67Ns)*	
Displacement voltage starting *for all types of earth fault (ANSI 64)*	
Setting ranges Pickup threshold V_E> (measured) Pickup threshold $3V_0$> (calculated) Delay time $T_{Delay\ pickup}$ Additional trip delay T_{VDELAY}	 1.8 to 170 V (in steps of 0.1 V) 10 to 225 V (in steps of 0.1 V) 0.04 to 320 s or ∞ (in steps of 0.01 s) 0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times Pickup time	 Approx. 60 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances Pickup threshold V_E (measured) Pickup threshold $3V_0$ (calculated) Delay times	 3 % of setting value or 0.3 V 3 % of setting value or 3 V 1 % of setting value or 10 ms
Phase detection for earth fault in an unearthed system	
Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges $V_{ph\ min}$ (earth-fault phase) $V_{ph\ max}$ (unfaulted phases)	 10 to 100 V (in steps of 1 V) 10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V
Earth-fault pickup *for all types of earth faults*	
Definite-time characteristic *(ANSI 50Ns)*	
Setting ranges Pickup threshold I_{EE}>, I_{EE}>> For sensitive input For normal input Delay times T for I_{EE}>, I_{EE}>> Dropout delay time T_{DO}	 0.001 to 1.5 A (in steps of 0.001 A) 0.25 to 175 A 1) (in steps of 0.01 A) 0 to 320 s or ∞ (in steps of 0.01 s) 0 to 60 s (in steps of 0.01 s)
Times Pickup times	 Approx. 60 ms (non-directional) Approx. 80 ms (directional
Dropout ratio	Approx. 0.95
Tolerances Pickup threshold I_{EE}>, I_{EE}>> Delay times	 2 % of setting value or 1 mA 1 % of setting value or 20 ms
Earth-fault pickup *for all types of earth faults*	
Inverse-time characteristic *(ANSI 51Ns)*	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Logarithmic inverse	$t = T_{IEEpmax} - T_{IEEp} \cdot \ln \frac{I}{I_{EEp}}$
Setting ranges Pickup threshold I_{EEp} For sensitive input For normal input User defined Time multiplier T Logarithmic inverse Time multiplier $T_{IEEp\ mul}$ Delay time T_{IEEp} Min time delay $T_{IEEpmin}$ Max. time delay $T_{IEEpmax}$	 0.001 A to 1.4 A (in steps of 0.001 A) 0.25 to 20 A 1) (in steps of 0.01 A) 0.1 to 4 s or ∞ (in steps of 0.01 s) 0.05 to 15 s or ∞ (in steps of 0.01 s) 0.1 to 4 s or ∞ (in steps of 0.01 s) 0 to 32 s (in steps of 0.01 s) 0 to 32 s (in steps of 0.01 s)

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

1) For I_{nom} = 1 A, all limits divided by 5.

Technical data

Times	
Pickup times	Approx. 60 ms (non-directional) Approx 80 ms (directional)
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold I_{EEp}	2 % of setting value or 1 mA
Delay times in linear range	7 % of reference value for 2 ≤ I/I_{EEp} ≤ 20 + 2 % current tolerance, or 70 ms
***Direction detection** for all types of earth-faults (ANSI 67Ns)*	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{Release\ direct.}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A[1] (in steps of 0.01 A)
Measuring method	cos φ and sin φ
Direction phasor $\varphi_{Correction}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{Reset\ delay}$	1 to 60 s (in steps of 1 s)
Angle correction for cable CT	
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current value $I1$, $I2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] (in steps of 0.01 A)
Tolerances	
Pickup measuring enable	2 % of the setting value or 1 mA
Angle tolerance	3 °
***High-impedance restricted earth-fault protection** (ANSI 87N) / single-phase overcurrent protection*	
Setting ranges	
Pickup thresholds I>, I>>	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1] or ∞ (in steps of 0.01 A)
Delay times T_I>, T_I>>	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for I/I_{nom} ≥ 0.5
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms

Intermittent earth-fault protection

Setting ranges		
Pickup threshold		
For I_E	I_{IE}>	0.25 to 175 A[1] (in steps of 0.01 A)
For $3I_0$	I_{IE}>	0.25 to 175 A[1] (in steps of 0.01 A)
For I_{EE}	I_{IE}>	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time	T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time	T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation	T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault		2 to 10 (in steps of 1)

1) At I_{nom} = 1 A, all limits divided by 5.

Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold I_{IE}>	3 % of setting value, or 50 mA[1]
Times T_V, T_{sum}, T_{res}	1 % of setting value or 10 ms
***Thermal overload protection** (ANSI 49)*	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom})$ ≤ 8	$t = \tau_{th} \cdot \ln \dfrac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8
***Auto-reclosure** (ANSI 79)*	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command

5

Technical data

Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
I>>, I>, I_p, I_{dir}>>, I_{dir}>, I_{pdir}
I_E>>, I_E>, I_{Ep}, I_{Edir}>>, I_{Edir}>, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts

Breaker failure protection (ANSI 50 BF)

Setting ranges	
Pickup threshold CB I>	0.2 to 5 A[1] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
start via control	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA)[1]
Delay time	1 % or 20 ms

Negative-sequence current detection (ANSI 46)

Definite-time characteristic (ANSI 46-1 and 46-2)

Setting ranges	
Pickup current I_2>, I_2>>	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A[1]
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{nom} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA[1]
Delay times	1 % or 10 ms

1) At I_{nom} = 1 A, all limits divided by 5.

Inverse-time characteristic (ANSI 46-TOC)

Setting ranges	
Pickup current	0.5 to 10 A [1] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A [1]
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA[1]
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms

Starting time monitoring for motors (ANSI 48)

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1] (in steps of 0.01)
Permissible starting time $T_{STARTUP}$	1 to 180 s (in steps of 0.1 s)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic	
For $I > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$
	$I_{STARTUP}$ = Rated motor starting current
	I = Actual current flowing
	$T_{STARTUP}$ = Tripping time for rated motor starting current
	t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1]
Delay time	5 % or 30 ms

Technical data

Restart inhibit for motors (ANSI 66)	
Setting ranges	
Motor starting current relative to rated motor current $I_{\text{MOTOR START}}/I_{\text{Motor Nom}}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{\text{Motor Nom}}$	1 to 6 A[1)] (in steps of 0.01 A)
Max. permissible starting time $T_{\text{Start Max}}$	3 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 min to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{\text{MIN. INHIBIT TIME}}$	0.2 min to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau \text{ at STOP}}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau \text{ RUNNING}}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{\text{restart}} = \Theta_{\text{rot max perm}} \cdot \frac{n_c - 1}{n_c}$ Θ_{restart} = Temperature limit below which restarting is possible $\Theta_{\text{rot max perm}}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{\text{rot}}/\Theta_{\text{rot trip}}$) n_c = Number of permissible start-ups from cold state
Undercurrent monitoring (ANSI 37)	
Signal from the operational measured values	Predefined with programmable logic
Temperature monitoring box (ANSI 38)	
Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	“Oil” or “Environment” or “Stator” or “Bearing” or “Other”
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

1) At I_{nom} = 1 A, all limits divided by 5.

Undervoltage protection (ANSI 27)	
Operating modes/measuring quantities	
3-phase	Positive-sequence component or smallest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$	
3-phase, phase-earth connection	10 to 210 V (in steps of 1 V)
3-phase, phase-phase connection	10 to 120 V (in steps of 1 V)
1-phase connection	10 to 120 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A[1)] (in steps of 0.01 A)
Dropout threshold $r \cdot V<(<)$	Max. 130 V for phase-phase voltages Max. 225 V phase-earth voltages
Times	
Pickup times $V<$, $V<<$, $V_1<$, $V_1<<$	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms
Overvoltage protection (ANSI 59)	
Operating modes/measuring quantities	
3-phase	Negative-sequence component or largest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$	
3-phase, phase-earth connection, largest phase-phase voltage	40 to 260 V (in steps of 1 V)
3-phase, phase-phase connection, largest phase-phase voltage	40 to 150 V (in steps of 1 V)
3-phase, negative-sequence voltage	2 to 150 V (in steps of 1 V)
1-phase connection	40 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Pickup times $V_2>$, $V_2>>$	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Technical data

Frequency protection (ANSI 81)	
Number of frequency elements	4
Setting ranges	
Pickup thresholds for f_{nom} = 50 Hz	45.5 to 54.5 Hz (in steps of 0.01 Hz)
Pickup thresholds for f_{nom} = 60 Hz	55.5 to 64.5 Hz (in steps of 0.01 Hz)
Delay times	0 to 100 s or ∞ (in steps of 0.01 s)
Undervoltage blocking, with positive-sequence voltage V_1	10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 150 ms
Dropout times	Approx. 150 ms
Dropout	
Δf = pickup value - dropout value	Approx. 20 mHz
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	10 mHz
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms
Fault locator (ANSI 21FL)	
Output of the fault distance	In Ω secondary, in km / mile of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km[1] (in steps of 0.0001) 0.001 to 3 Ω/mile[1] (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for $30° \leq \varphi K \leq 90°$ and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

Additional functions	
Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range Tolerance[2]	10 to 200 % I_{nom} 1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages V_{L1-E}, V_{L2-E}, V_{L3-E} Phase-to-phase voltages V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range Tolerance[2]	10 to 120 % V_{nom} 1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range Tolerance[2]	0 to 120 % S_{nom} 1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %
P, active Power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}
Range Tolerance[2]	0 to 120 % S_{nom} 2 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\cos\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range Tolerance[2]	0 to 120 % S_{nom} 2 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\sin\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
$\cos\varphi$, power factor (p.f.)	Total and phase segregated
Range Tolerance[2]	- 1 to + 1 3 % for $\lvert\cos\varphi\rvert \geq 0.707$
Frequency f	In Hz
Range Tolerance[2]	$f_{nom} \pm 5$ Hz 20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range Tolerance[2]	0 to 400 % 5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\,Trip}$	In %
Range Tolerance[2]	0 to 400 % 5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\,Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\,real}$, $I_{EE\,reactive}$	In A (kA) primary and in mA secondary
Range Tolerance[2]	0 mA to 1600 mA 2 % of measured value or 1 mA
Measuring transducer	
Operating range	0 to 24 mA
Accuracy range	1 to 20 mA
Tolerance[2]	1.5 %, relative to rated value of 20 mA
For standard usage of the measurement transducer for pressure and temperature monitoring	
Operating measured value	Pressure in hPa
Operating range (presetting)	0 hPa to 1200 hPa
Operating measured value temperature	Temp in °C / °F
Operating range (presetting)	0 °C to 240 °C or 32 °F to 464 °F
RTD-box	See section "Temperature monitoring box"
Long-term averages	
Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages	
of currents	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA)
of real power	P_{dmd} in W (kW, MW)
of reactive power	Q_{dmd} in VAr (kVAr, MVAr)
of apparent power	S_{dmd} in VAr (kVAr, MVAr)

1) At I_{nom} = 1 A, all limits multiplied with 5.

1) At rated frequency.

Technical data

Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	$V_{L1\text{-}E}$, $V_{L2\text{-}E}$, $V_{L3\text{-}E}$ V_1 (positive-sequence component) $V_{L1\text{-}L2}$, $V_{L2\text{-}L3}$, $V_{L3\text{-}L1}$
Min./Max. values for power	S, P, Q, cos φ, frequency
Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}
Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for $I>I_{balance\ limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for $V>V_{lim}$
Current sum	$\lvert i_{L1} + i_{L2} + i_{L3} + k_{iE} \cdot i_E \rvert$ > limit value, with $k_{iE} = \frac{I_{earth}\text{ CT PRIM} / I_{earth}\text{ CT SEC}}{\text{CT PRIM / CT SEC}}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 5 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 sam/cyc) 1 sample/1.04 ms (16 sam/cyc)

Energy/power	
Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance[1)]	≤ 5 % for $I > 0.5\ I_{nom}$, $V > 0.5\ V_{nom}$ and $\lvert\cos\varphi\rvert$ (p.f.) ≥ 0.707
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits
Circuit-breaker wear	
Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life)
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})
Trip circuit monitoring	
With one or two binary inputs	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker / switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	Control via menu, control with control keys
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

1) At rated frequency.

5

Technical data

Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Selection and ordering data

Description	Order No.
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□*

see next page

Housing, binary inputs (BI) and outputs (BO), measuring transducer

Description	Code
Housing 1/2 19", 11 BI, 8 BO, 1 live status contact	1
Housing 1/2 19", 24 BI, 11 BO, 4 (2) power relays, 1 live status contact	2
Housing 1/2 19", 20 BI, 11 BO, 2 measuring transducer inputs, 4 power relays, 1 live status contact	3
Housing 1/1 19", 37 BI, 14 BO, 8 (4) power relays, 1 live status contact	5
Housing 1/1 19", 33 BI, 14 BO, 2 measuring transducer inputs, 8 (4) power relays, 1 live status contact	6

Measuring inputs (3 x V, 4 x I)

Description	Code
I_{ph} = 1 A[1)], I_e = 1 A[1)] (min. = 0.05 A) Position 15 only with *A, C, E, G*	1
I_{ph} = 1 A[1)], I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	2
I_{ph} = 5 A[1)], I_e = 5 A[1)] (min. = 0.25 A) Position 15 only with *A, C, E, G*	5
I_{ph} = 5 A[1)], I_e = sensitive (min. = 0.001 A) Position 15 only with *B, D, F, H*	6
I_{ph} = 5 A[1)], I_e = 1 A[1)] (min. = 0.05 A) Position 15 only with *A, C, E, G*	7

Rated auxiliary voltage (power supply, indication voltage)

Description	Code
24 to 48 V DC, threshold binary input 19 V DC[3)]	2
60 to 125 V DC[2)], threshold binary input 19 V DC[3)]	4
110 to 250 V DC[2)], 115 to 230 V[4)] AC, threshold binary input 88 V DC[3)]	5

Unit version

Description	Code
For panel surface mounting, plug-in terminals, detached operator panel	A
For panel surface mounting, 2-tier terminals top/bottom	B
For panel surface mounting, screw-type terminals, detached operator panel	C
For panel flush mounting, plug-in terminals (2/3 pin connector)	D
For panel flush mounting , screw-type terminals (direct connection/ring-type cable lugs)	E
Surface-mounting housing, screw-type terminals (direct connection/ring-type cable lugs), without operator panel, panel mounting in low-voltage housing	F
Surface-mounting housing, plug-in terminals, without operator panel, panel mounting in low-voltage housing	G

Region-specific default settings/function versions and language settings

Description	Code
Region DE, 50 Hz, IEC, language: German, selectable	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), selectable	B
Region US, 60 Hz, ANSI, language: English (US), selectable	C
Region FR, IEC/ANSI language: French, selectable	D
Region World, IEC/ANSI language: Spanish, selectable	E

System interface (Port B): Refer to page 5/148

Description	Code
No system interface	0
Protocols see page 5/148	

Service interface (Port C)

Description	Code
No interface at rear side	0
DIGSI 4/modem, electrical RS232	1
DIGSI 4/modem/RTD-box[5)], electrical RS485	2
DIGSI 4/modem/RTD-box[5)6)], optical 820 nm wavelength, ST connector	3

Measuring/fault recording

Description	Code
Slave pointer, mean values, min/max values, fault recording	3

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected per binary input by means of jumpers.

4) 230 V AC, starting from unit version .../EE

5) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".

6) When using the temperature monitoring box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

Selection and ordering data

Description	Order No.
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□*

Designation				ANSI No.	Description	Order code
Basic version					Control	
				50/51	Time-overcurrent protection	
					$I>$, $I>>$, I_p, reverse interlocking	
				50N/51N	Earth-fault protection	
					$I_E>$, $I_E>>$, I_{Ep}	
				50N/51N	Insensitive earth-fault protection via	
					IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
				49	Overload protection (with 2 time constants)	
				46	Phase balance current protection	
					(negative-sequence protection)	
				37	Undercurrent monitoring	
				47	Phase sequence	
				59N/64	Displacement voltage	
				50BF	Breaker failure protection	
				74TC	Trip circuit supervision	
					4 setting groups, cold-load pickup	
					Inrush blocking	
				86	Lockout	F A
■			V, f	27/59	Under-/overvoltage	
				81 O/U	Under-/overfrequency	F E
■		IEF	V, f	27/59	Under-/overvoltage	
				81 O/U	Under-/overfrequency	
					Intermittent earth fault	P E
■	Dir			67/67N	Direction determination for overcurrent, phases and earth	
				47	Phase sequence	F C
■	Dir		V, f	67/67N	Direction determination for overcurrent, phases and earth	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	F G
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth	
					Intermittent earth fault	P C
Directional earth-fault detection ■	Dir			67/67N	Direction determination for overcurrent, phases and earth	
				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	F D 2)
Directional earth-fault detection ■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth	
				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	
					Intermittent earth fault	P D 2)
Directional earth-fault detection ■				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	F B 2)
Directional earth-fault detection ■	Motor		V, f	67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	H F 2)

■ Basic version included

V, f = Voltage, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

continued on next page

Selection and ordering data

Description	Order No.	Order code
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□–□□□□*	

Designation				ANSI No.	Description	Order code
Basic version					Control	
				50/51	Time-overcurrent protection	
					$I>$, $I>>$, I_p, reverse interlocking	
				50N/51N	Earth-fault protection	
					$I_E>$, $I_E>>$, I_{Ep}	
				50N/51N	Earth-fault protection via insensitive	
					IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} [1)]	
				49	Overload protection (with 2 time constants)	
				46	Phase balance current protection	
					(negative-sequence protection)	
				37	Undercurrent monitoring	
				47	Phase sequence	
				59N/64	Displacement voltage	
				50BF	Breaker failure protection	
				74TC	Trip circuit supervision	
					4 setting groups, cold-load pickup	
					Inrush blocking	
				86	Lockout	
Directional earth-fault detection ■	Motor Dir		*V, f*	67/67N	Direction determination for overcurrent, phases and earth	
				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	*H H* [2)]
Directional earth-fault detection ■	Motor Dir	IEF	*V, f*	67/67N	Direction determination for overcurrent, phases and earth	
				67Ns	Directional sensitive earth-fault detection	
				87N	High-impedance restricted earth fault	
					Intermittent earth fault	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	*R H* [2)]
■	Motor Dir		*V, f*	67/67N	Direction determination for overcurrent, phases and earth	
				48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	
				27/59	Under-/overvoltage	
				81O/U	Under-/overfrequency	*H G*
■	Motor			48/14	Starting time supervision, locked rotor	
				66/86	Restart inhibit	*H A*
ARC, fault locator					Without	*0*
				79	With auto-reclosure	*1*
				21FL	With fault locator	*2*
				79, 21FL	With auto-reclosure, with fault locator	*3*
ATEX100 Certification For protection of explosion-protected motors (increased-safety type of protection “e”)						*Z X 9 9*

■ Basic version included

V, *f* = Voltage, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Order number for system port B

Description	Order No.	Order code
7SJ63 multifunction protection relay	*7SJ63□□ – □□□□□ – □□□□–□□□*	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector [1])	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector [1])	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector [1])	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector [2])	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector [2])	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector (EN 100)[2])	9	L 0 S

1) Not with position 9 = "B"; if 9 = "B", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "B".
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "B".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "B".

Sample order

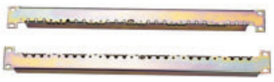
Position		Order No. + Order code
		7SJ6325-5EC91-3FC1+L0G
6	I/O's: 24 BI/11 BO, 1 live status contact	2
7	Current transformer: 5 A	5
8	Power supply: 110 to 250 V DC, 115 V AC to 230 V AC	5
9	Unit version: Flush-mounting housing, screw-type terminals	E
10	Region: US, English language (US); 60 Hz, ANSI	C
11	Communication: System interface: DNP 3.0, RS485	9 L0G
12	Communication: DIGSI 4, electrical RS232	1
13	Measuring/fault recording: Extended measuring and fault records	3
14/15	Protection function package: Basic version plus directional TOC	FC
16	With auto-reclosure	1

Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		*7XS5460-0AA00*
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		*7XS5410-0AA00*
Temperature monitoring box		
24 to 60 V AC/DC		*7XV5662-2AD10*
90 to 240 V AC/DC		*7XV5662-5AD10*
Varistor/Voltage Arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		*C53207-A401-D76-1*
240 Vrms; 600 A; 1S/S 1088		*C53207-A401-D77-1*
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		*7XV5100-4*
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		*7XV5103-7AA05*
- length 25 m /82 ft		*7XV5103-7AA25*
- length 50 m /164 ft		*7XV5103-7AA50*
Manual for 7SJ62/63/64,		
English		*C53000-G1140-C147-6*
French		*C53000-G1177-C147-2*
Spanish		*C53000-G1178-C147-2*
Catalog SIP 3.1 Spanish		*E50001-K4403-A111-A1-7800*

5

Accessories


LSP2289-afp.eps

Mounting rail


LSP2090-afp.eps

2-pin connector


LSP2091-afp.eps

3-pin connector


LSP2093-afp.eps

Short-circuit links for current terminals


LSP2092-afp.eps

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin	C73334-A1-C35-1	1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP [1)]
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP [1)]
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP [1)]
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP [1)]
Crimping tool for Type III+	0-539635-1	1	AMP [1)]
and matching female	0-539668-2	1	AMP [1)]
Crimping tool for CI2	0-734372-1	1	AMP [1)]
and matching female	1-734387-1	1	AMP [1)]
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

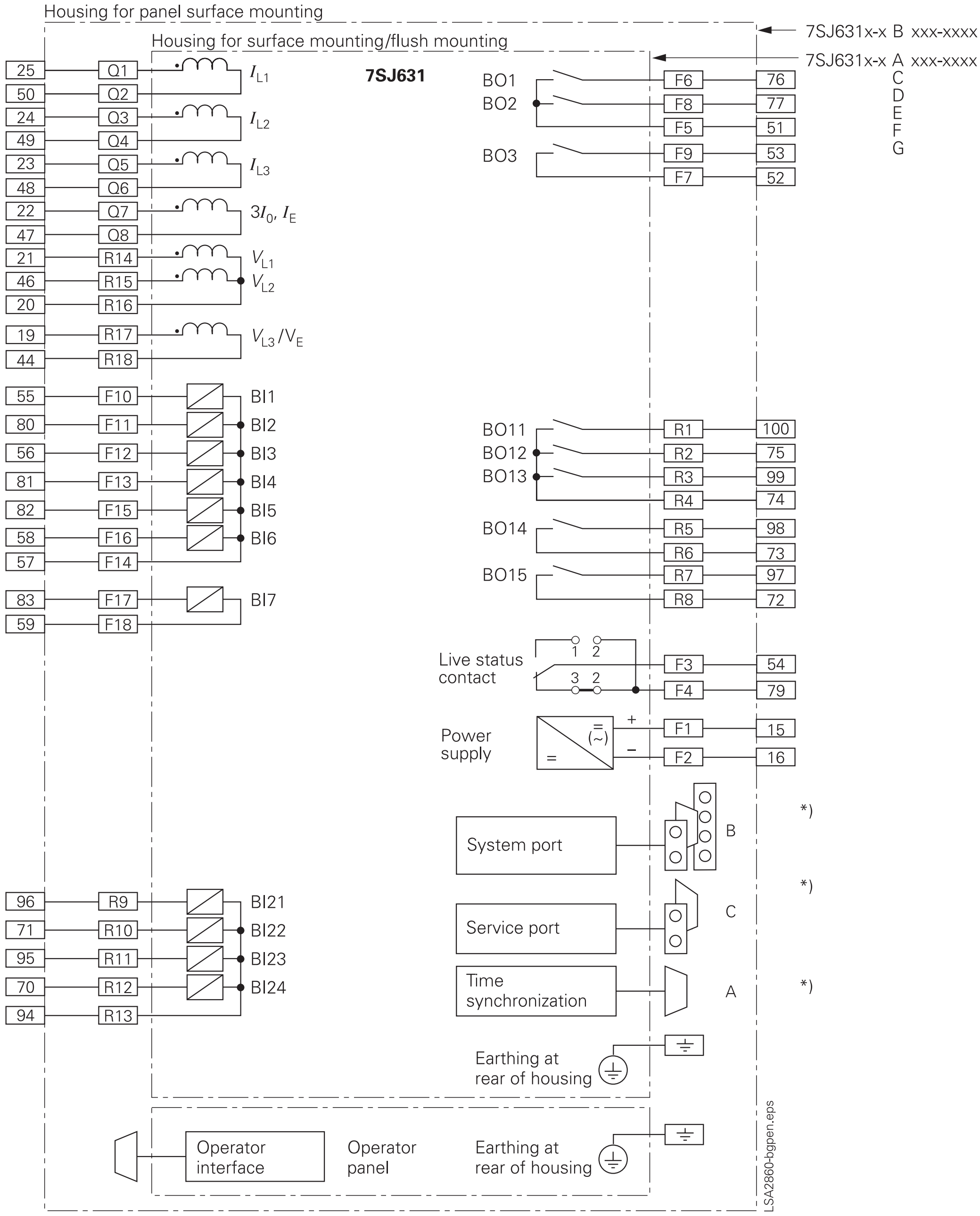


Fig. 5/137
7SJ631 connection diagram

*) For pinout of communication ports see part 16 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siprotec.com).

Connection diagram

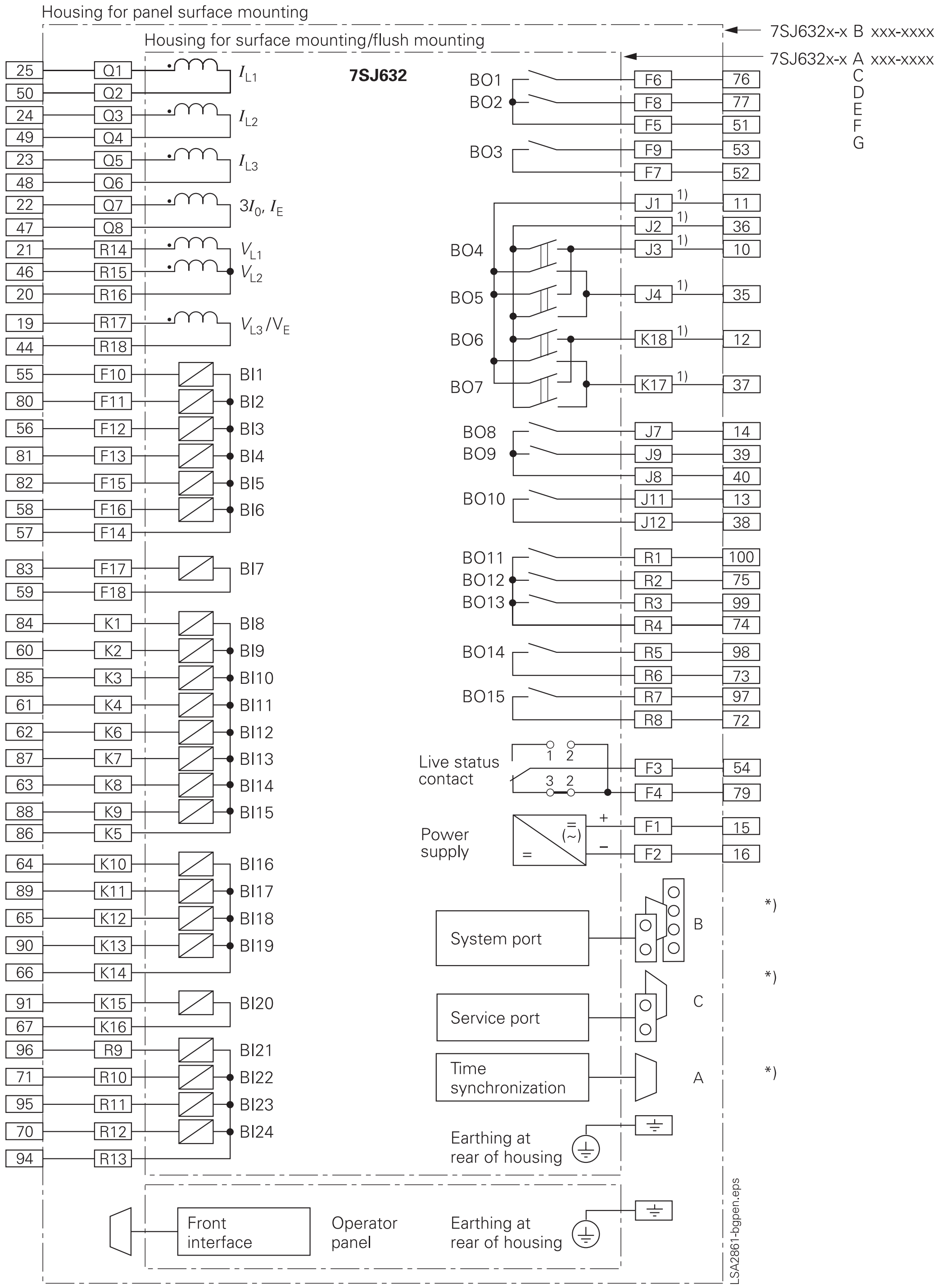


Fig. 5/138
7SJ632 connection diagram

*) For pinout of communication ports see part 16 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siprotec.com).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7. If used for protection purposes only one binary output of a pair can be used.

Connection diagram

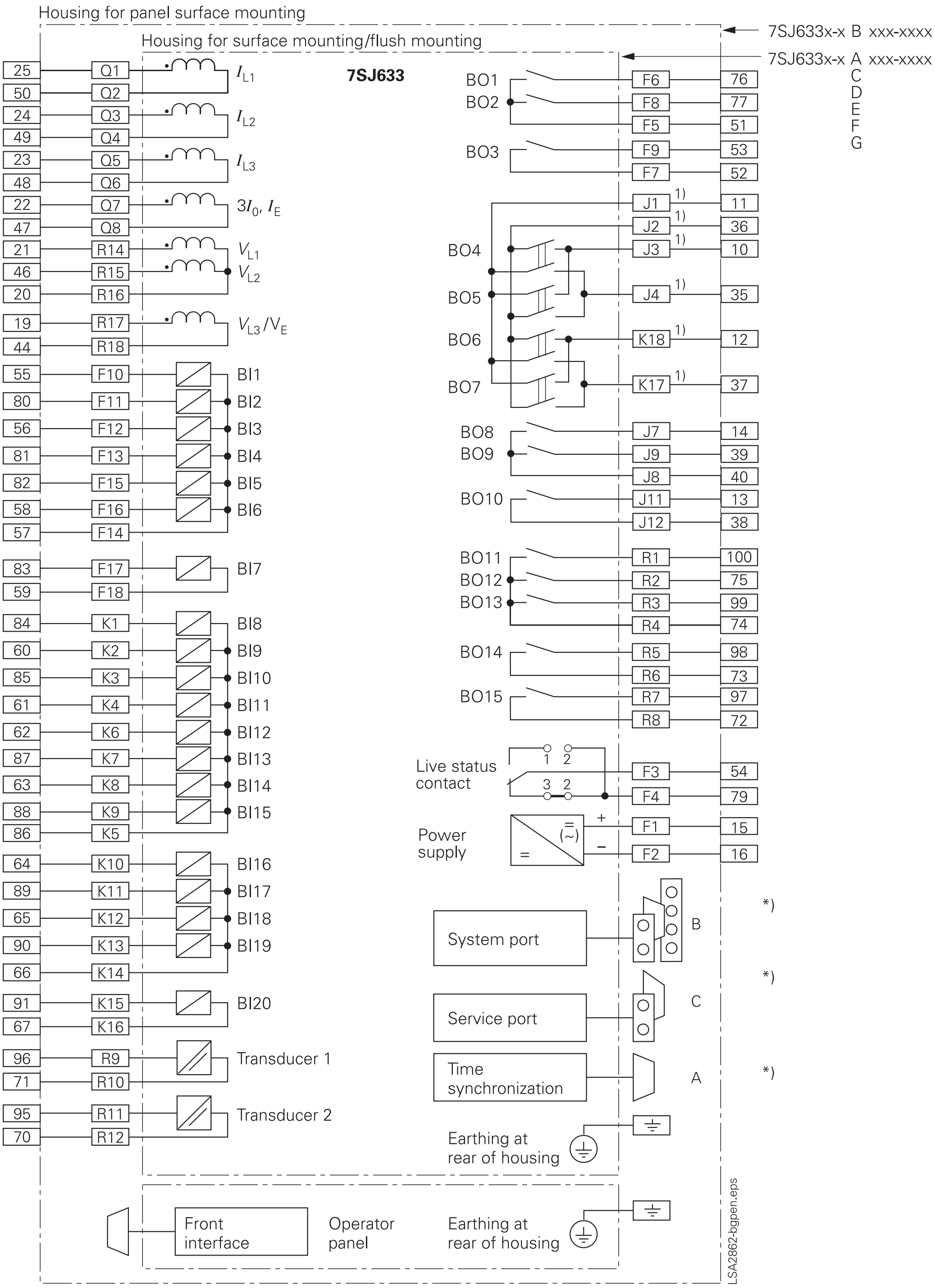


Fig. 5/139
7SJ633 connection diagram

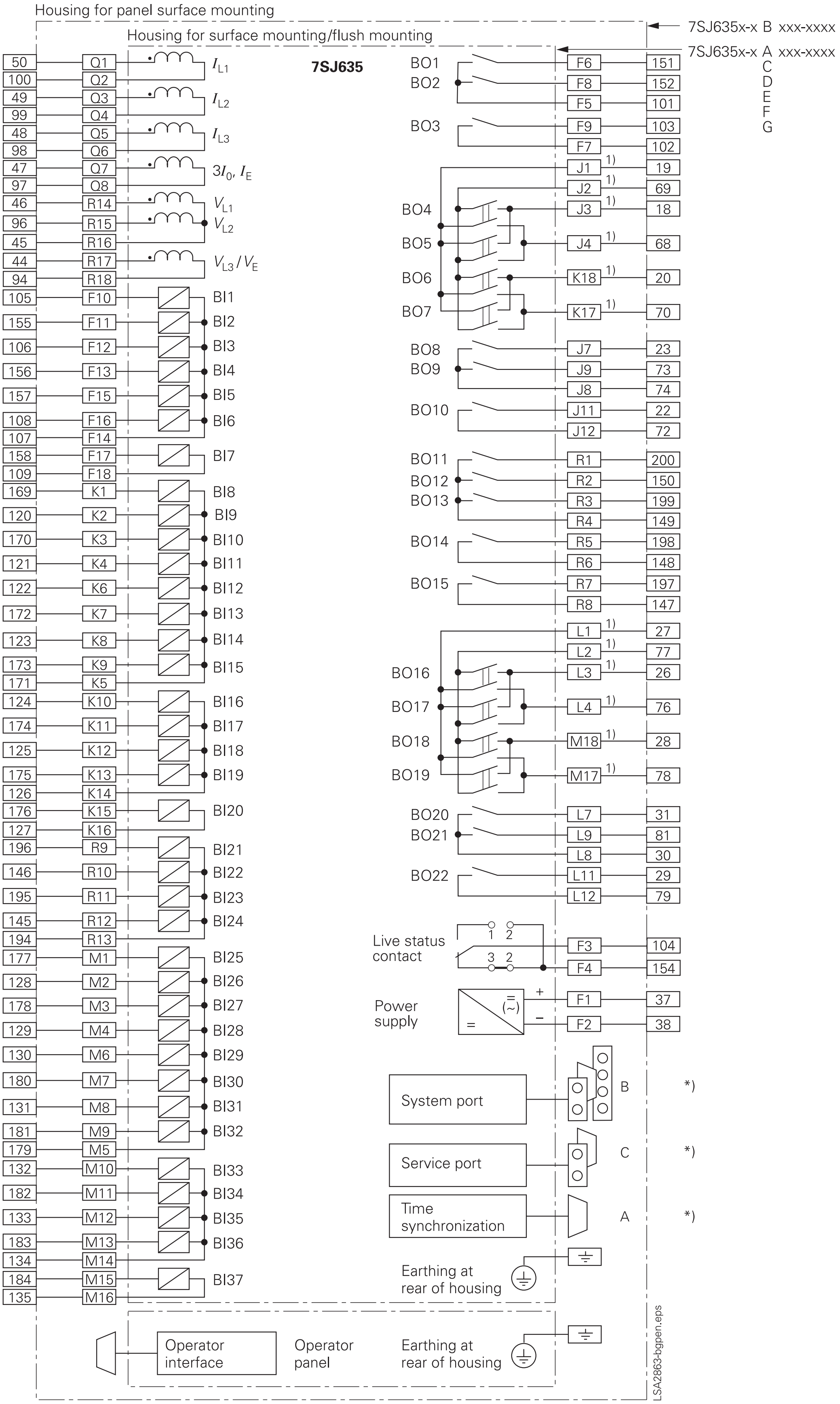
*) For pinout of communication ports see part 16 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siprotec.com).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7. If used for protection purposes only one binary output of a pair can be used.

5

Connection diagram



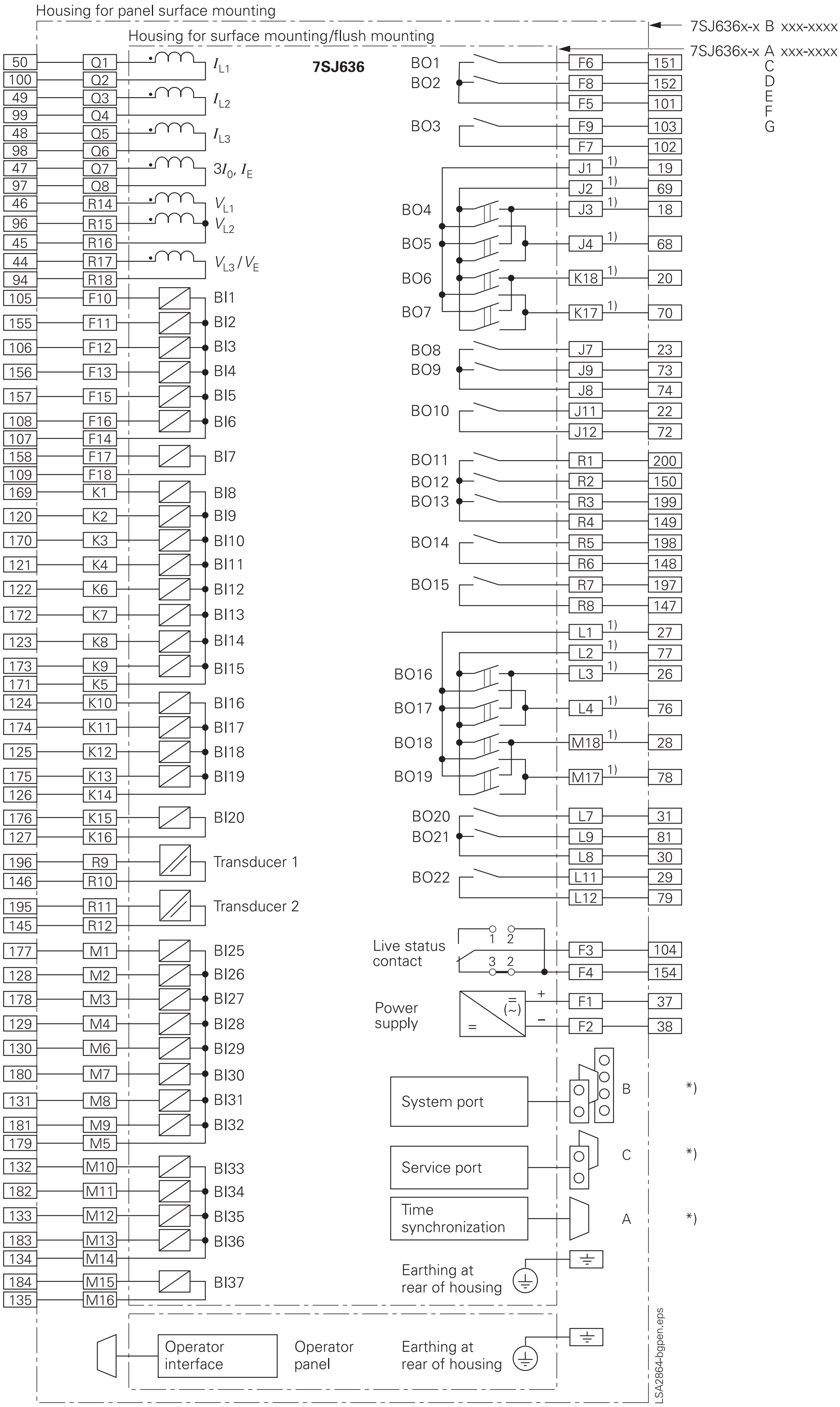
*) For pinout of communication ports see part 16 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siprotec.com).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7, BO16/BO17 and BO18/BO19. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/140
7SJ635 connection diagram

Connection diagram



*) For pinout of communication ports see part 16 of this catalog.

For the allocation of the terminals of the panel surface-mounting version refer to the manual (http://www.siprotec.com).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO4/BO5, BO6/BO7, BO16/BO17 and BO18/BO19. If used for protection purposes only one binary output of a pair can be used.

Fig. 5/141
7SJ636 connection diagram

SIPROTEC 4 7SJ64
Multifunction Protection Relay with Synchronization

LSP2316-afpen.tif

Fig. 5/142
SIPROTEC 4 7SJ64 multifunction protection relay

Description

The SIPROTEC 4 7SJ64 can be used as a protective control and monitoring relay for distribution feeders and transmission lines of any voltage in networks that are earthed (grounded), low-resistance earthed, unearthed, or of a compensated neutral point structure. The relay is suited for networks that are radial or looped, and for lines with single or multi-terminal feeds. The SIPROTEC 4 7SJ64 is equipped with a synchronization function which provides the operation modes 'synchronization check' (classical) and 'synchronous/asynchronous switching' (which takes the CB mechanical delay into consideration). Motor protection comprises undercurrent monitoring, starting time supervision, restart inhibit, locked rotor.

The 7SJ64 is the only relay of the 7SJ6 family featuring "flexible protection functions". Up to 20 protection functions can be added according to individual requirements. Thus, for example, a third 50 stage or reverse power protection can be implemented.

The relay provides easy-to-use local control and automation functions. The number of controllable switchgear depends only on the number of available inputs and outputs. The integrated programmable logic (CFC) allows the user to implement their own functions, e.g. for the automation of switchgear (interlocking). CFC capacity is much larger compared to 7SJ62/63 due to extended CPU power. The user is able to generate user-defined messages as well.

The flexible communication interfaces are open for modern communication architectures with control systems.

Function overview

Protection functions

- Time-overcurrent protection
- Directional time-overcurrent protection
- Sensitive dir./non-dir. earth-fault detection
- Displacement voltage
- Intermittent earth-fault protection
- High-impedance restricted earth fault
- Inrush restraint
- Motor protection
- Overload protection
- Temperature monitoring
- Under-/overvoltage protection
- Under-/overfrequency protection
- Rate-of-frequency-change protection
- Power protection (e.g. reverse, factor)
- Breaker failure protection
- Negative-sequence protection
- Phase-sequence monitoring
- Synchronization
- Auto-reclosure
- Fault locator
- Lockout

Control functions/programmable logic

- Flexible number of switching devices
- Position of switching elements is shown on the graphic display
- Local/remote switching via key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- Extended user-defined logic with CFC (e.g. interlocking)

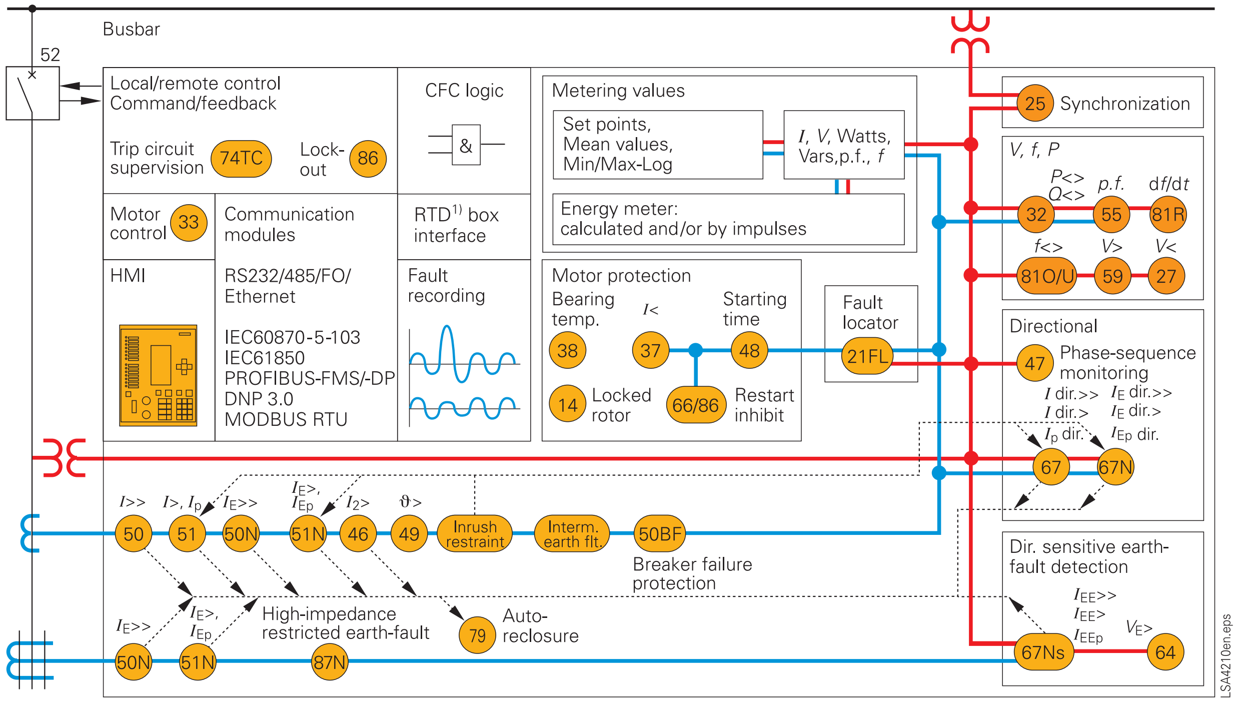
Monitoring functions

- Operational measured values V, I, f,...
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Slave pointer
- Trip circuit supervision
- Fuse failure monitor
- 8 oscillographic fault records

Communication interfaces

- System interface
  – IEC 60870-5-103, IEC 61850
  – PROFIBUS-FMS / DP
  – DNP 3.0 / MODBUS RTU
- Service interface for DIGSI 4 (modem)
- Additional interface for temperature detection (RTD-box)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/DCF77

Application



[1] RTD = resistance temperature detector

Fig. 5/143 Function diagram

The SIPROTEC 4 7SJ64 unit is a numerical protection relay that also performs control and monitoring functions and therefore supports the user in cost-effective power system management, and ensures reliable supply of electric power to the customers. Local operation has been designed according to ergonomic criteria. A large, easy-to-read graphic display was a major design aim.

Control

The integrated control function permits control of disconnect devices (electrically operated/motorized switches) or circuit-breakers via the integrated operator panel, binary inputs, DIGSI 4 or the control and protection system (e.g. SICAM). The present status (or position) of the primary equipment can be displayed. 7SJ64 supports substations with single and duplicate busbars. The number of elements that can be controlled (usually 1 to 5) is only restricted by the number of inputs and outputs available. A full range of command processing functions is provided.

Programmable logic

The integrated logic characteristics (CFC) allow users to implement their own functions for automation of switchgear (interlocking) or a substation via a graphic user interface. Due to extended CPU power, the programmable logic capacity is much larger compared to 7SJ62/63. The user can also generate user-defined messages.

Line protection

The 7SJ64 units can be used for line protection of high and medium-voltage networks with earthed, low-resistance earthed, isolated or compensated neutral point.

Synchronization

In order to connect two components of a power system, the relay provides a synchronization function which verifies that switching ON does not endanger the stability of the power system.

The synchronization function provides the operation modes ‘synchro-check’ (classical) and ‘synchronous/asynchronous switching’ (which takes the c.-b. mechanical delay into consideration).

Motor protection

When protecting motors, the relays are suitable for asynchronous machines of all sizes.

Transformer protection

The 7SJ64 units perform all functions of backup protection supplementary to transformer differential protection. The inrush suppression effectively prevents tripping by inrush currents.

The high-impedance restricted earth-fault protection detects short-circuits and insulation faults of the transformer.

Backup protection

The relays can be used universally for backup protection.

Flexible protection functions

By configuring a connection between a standard protection logic and any measured or derived quantity, the functional scope of the relays can be easily expanded by up to 20 protection stages or protection functions.

Metering values

Extensive measured values, limit values and metered values permit improved system management.

Application

ANSI No.	IEC	Protection functions
50, 50N	$I>$, $I>>$ $I_E>$, $I_E>>$	Definite-time overcurrent protection (phase/neutral)
50, 50N	$I>>>$, $I>>>>$ $I_E>>>$, $I_E>>>>$	Additional definite-time overcurrent protection stages (phase/neutral) via flexible protection functions
51, 51N	I_p, I_{Ep}	Inverse-time overcurrent protection (phase/neutral)
67, 67N	$I_{dir}>$, $I_{dir}>>$, $I_{p\ dir}$ $I_{Edir}>$, $I_{Edir}>>$, $I_{Ep\ dir}$	Directional time-overcurrent protection (definite/inverse, phase/neutral) Directional comparison protection
67Ns/50Ns	$I_{EE}>$, $I_{EE}>>$, I_{EEp}	Directional/non-directional sensitive earth-fault detection
–		Cold load pick-up (dynamic setting change)
59N/64	V_E, $V_0>$	Displacement voltage, zero-sequence voltage
–	$I_{IE}>$	Intermittent earth fault
87N		High-impedance restricted earth-fault protection
50BF		Breaker failure protection
79M		Auto-reclosure
25		Synchronization
46	$I_2>$	Phase-balance current protection (negative-sequence protection)
47	$V_2>$, phase seq.	Unbalance-voltage protection and/or phase-sequence monitoring
49	$\vartheta>$	Thermal overload protection
48		Starting time supervision
14		Locked rotor protection
66/86		Restart inhibit
37	$I<$	Undercurrent monitoring
38		Temperature monitoring via external device, e.g. bearing temperature monitoring
27, 59	$V<$, $V>$	Underfrequency/overvoltage protection
32	$P<>$, $Q<>$	Reverse-power, forward-power protection
55	$\cos\varphi$	Power factor protection
81O/U	$f>$, $f<$	Overvoltage/underfrequency protection
81R	df/dt	Rate-of-frequency-change protection
21FL		Fault locator

Construction

Connection techniques and housing with many advantages

1/3, 1/2 and 1/1-rack sizes

These are the available housing widths of the 7SJ64 relays, referred to a 19” module frame system. This means that previous models can always be replaced. The height is a uniform 244 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.
It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 5/146), or without operator panel, in order to allow optimum operation for all types of applications.

Fig. 5/144
Flush-mounting housing with screw-type terminals

Fig. 5/145
Front view of 7SJ64 with 1/3x19" housing

Fig. 5/146
Housing with plug-in terminals and detached operator panel

Fig. 5/148
Communication interfaces in a sloped case in a surface-mounting housing

Fig. 5/147
Surface-mounting housing with screw-type terminals

5

Protection functions

Time-overcurrent protection (ANSI 50, 50N, 51, 51N)

This function is based on the phase-selective measurement of the three phase currents and the earth current (four transformers). Two definite-time overcurrent protection elements (DMT) exist both for the phases and for the earth. The current threshold and the delay time can be set in a wide range. In addition, inverse-time overcurrent protection characteristics (IDMTL) can be activated.
With the "flexible protection functions", further definite-time overcurrent stages can be implemented in the 7SJ64 unit.

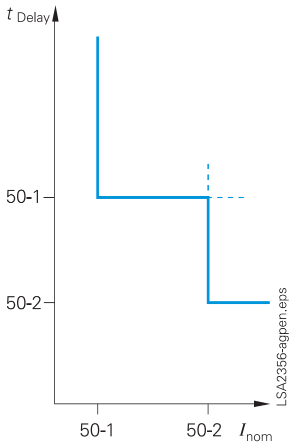


Fig. 5/149
Definite-time overcurrent protection

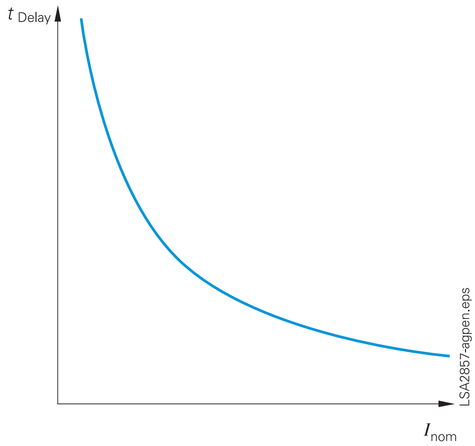


Fig. 5/150
Inverse-time overcurrent protection

Available inverse-time characteristics

Characteristics acc. to	ANSI/IEEE	IEC 60255-3
Inverse	•	•
Short inverse	•	
Long inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	

Reset characteristics

For easier time coordination with electromechanical relays, reset characteristics according to ANSI C37.112 and IEC 60255-3 / BS 142 standards are applied. When using the reset characteristic (disk emulation), a reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (thus: disk emulation).

User-definable characteristics

Instead of the predefined time characteristics according to ANSI, tripping characteristics can be defined by the user for phase and earth units separately. Up to 20 current/time value pairs may be programmed. They are set as pairs of numbers or graphically in DIGSI 4.

Inrush restraint

The relay features second harmonic restraint. If the second harmonic is detected during transformer energization, pickup of non-directional and directional normal elements are blocked.

Cold load pickup/dynamic setting change

For directional and nondirectional time-overcurrent protection functions the initiation thresholds and tripping times can be switched via binary inputs or by time control.

Protection functions

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and earth protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristic is offered. The tripping characteristic can be rotated about ± 180 degrees.

By means of voltage memory, directionality can be determined reliably even for close-in (local) faults. If the switching device closes onto a fault and the voltage is too low to determine direction, directio- nality (directional decision) is made with voltage from the voltage memory. If no voltage exists in the memory, tripping occurs according to the coordination schedule.

For earth protection, users can choose whether the direction is to be determined via zero-sequence system or negative-sequence system quantities (selectable).
Using negative-sequence variables can be advantageous in cases where the zero voltage tends to be very low due to unfavorable zero-sequence impedances.

Directional comparison protection (cross-coupling)

It is used for selective protection of sections fed from two sources with instantaneous tripping, i.e. without the disadvantage of time coordination. The directional comparison protection is suitable if the distances between the protection stations are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated time-overcurrent protection is used for complete selective backup protection. If operated in a closed-circuit connection, an interruption of the transmission line is detected.

(Sensitive) directional earth-fault detection (ANSI 64, 67Ns/67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0. For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated.

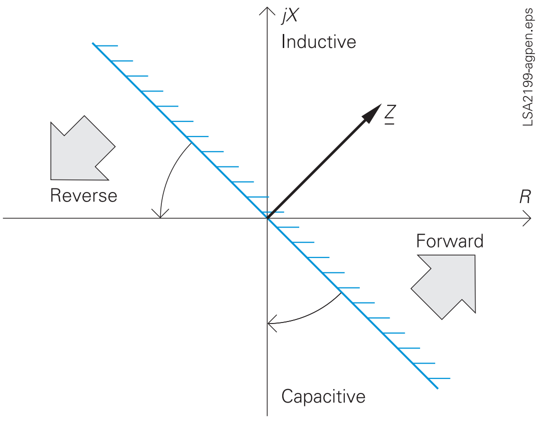


Fig. 5/151
Directional characteristic of the directional time-overcurrent protection

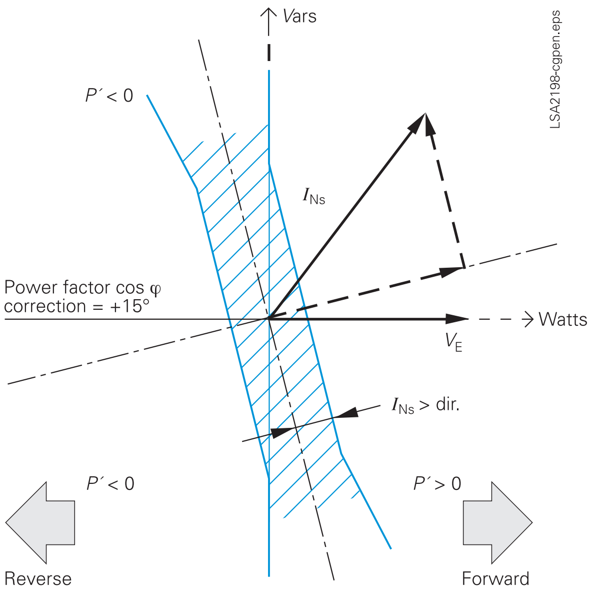


Fig. 5/152
Directional determination using cosine measurements for compensated networks

For special network conditions, e.g. high-resistance earthed networks with ohmic-capacitive earth-fault current or low-resistance earthed networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees.

Two modes of earth-fault direction detection can be implemented: tripping or "signalling only mode".

It has the following functions:

- TRIP via the displacement voltage V_E.
- Two instantaneous elements or one instantaneous plus one user-defined characteristic.
- Each element can be set in forward, reverse, or non-directional.
- The function can also be operated in the insensitive mode, as an additional short-circuit protection.

(Sensitive) earth-fault detection (ANSI 50Ns, 51Ns/50N, 51N)

For high-resistance earthed networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT).

The function can also be operated in the insensitive mode, as an additional short-circuit protection.

Protection functions

Intermittent earth-fault protection

Intermittent (re-striking) faults occur due to insulation weaknesses in cables or as a result of water penetrating cable joints. Such faults either simply cease at some stage or develop into lasting short-circuits. During intermittent activity, however, star-point resistors in networks that are impedance-earthed may undergo thermal overloading. The normal earth-fault protection cannot reliably detect and interrupt the current pulses, some of which can be very brief.
The selectivity required with intermittent earth faults is achieved by summating the duration of the individual pulses and by triggering when a (settable) summed time is reached. The response threshold I_{IE}> evaluates the r.m.s. value, referred to one systems period.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

In line protection, the two-element phase-balance current/negative-sequence protection permits detection on the high side of high-resistance phase-to-phase faults and phase-to-earth faults that are on the low side of a transformer (e.g. with the switch group Dy 5). This provides backup protection for high-resistance faults beyond the transformer.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuance of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g. of an upstream (higher-level) protection relay. Breaker failure is detected if, after a trip command, current is still flowing in the faulted circuit. As an option, it is possible to make use of the circuit-breaker position indication.

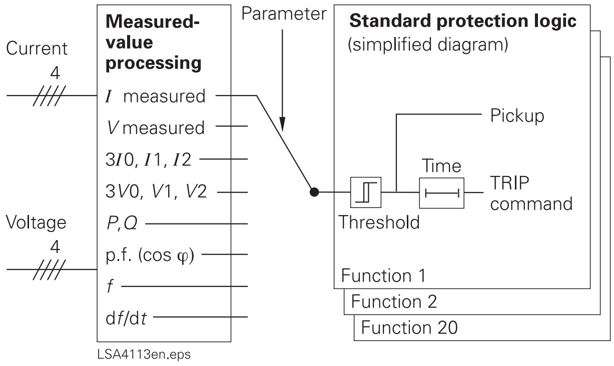


Fig. 5/153 Flexible protection functions

Auto-reclosures (ANSI 79)

Multiple reclosures can be defined by the user and lockout will occur if a fault is present after the last reclosure. The following functions are possible:

- 3-pole ARC for all types of faults
- Separate settings for phase and earth faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)
- Starting of the ARC depends on the trip command selection (e.g. 46, 50, 51, 67)
- Blocking option of the ARC via binary inputs
- ARC can be initiated externally or via CFC
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- Dynamic setting change of the directional and non-directional elements can be activated depending on the ready AR
- The AR CLOSE command can be given synchronous by use of the synchronization function.

Flexible protection functions

The 7SJ64 units enable the user to easily add on up to 20 protective functions. To this end, parameter definitions are used to link a standard protection logic with any chosen characteristic quantity (measured or derived quantity) (Fig. 5/153). The standard logic consists of the usual protection elements such as the pickup message, the parameter-definable delay time, the TRIP command, a blocking possibility, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated as greater than or less than stages. All stages operate with protection priority.

Protection stages/functions attainable on the basis of the available characteristic quantities:

Function	ANSI No.
I>, I_E>	50, 50N
V<, V>, V_E>	27, 59, 64
$3I_0$>, I_1>, I_2>, $3V_0$>, V_1><, V_2><	50N, 46 59N, 47
P><, Q><	32
cos φ (p.f.)><	55
f><	81O, 81U
df/dt><	81R

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Third independent I>>> stage (ANSI 50-3)
- Rate-of-frequency-change protection (ANSI 81R)

Protection functions

Synchronization (ANSI 25)

In case of switching ON the circuit-breaker, the units can check whether the two subnetworks are synchronized (classic synchro-check). Furthermore, the synchronizing function may operate in the "Synchronous/asynchronous switching" mode. The unit then distinguishes between synchronous and asynchronous networks:
In synchronous networks, frequency differences between the two subnetworks are almost non-existant. In this case, the circuit-breaker operating time does not need to be considered. Under asynchronous condition, however, this difference is markedly larger and the time window for switching is shorter. In this case, it is recommended to consider the operating time of the circuit-breaker. The command is automatically pre-dated by the duration of the operating time of the circuit-breaker, thus ensuring that the contacts of the CB close at exactly the right time.

Up to 4 sets of parameters for the synchronizing function can be stored in the unit. This is an important feature when several circuit-breakers with different operating times are to be operated by one single relay.

Thermal overload protection (ANSI 49)

For protecting cables and transformers, an overload protection with an integrated pre-warning element for temperature and current can be applied. The temperature is calculated using a thermal homogeneous-body model (according to IEC 60255-8), which takes account both of the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted accordingly. Thus, account is taken of the previous load and the load fluctuations.

For thermal protection of motors (especially the stator), a further time constant can be set so that the thermal ratios can be detected correctly while the motor is rotating and when it is stopped. The ambient temperature or the temperature of the coolant can be detected serially via an external temperature monitoring box (resistance-temperature detector box, also called RTD- box). The thermal replica of the overload function is automatically adapted to the ambient conditions. If there is no RTD-box it is assumed that the ambient temperatures are constant.

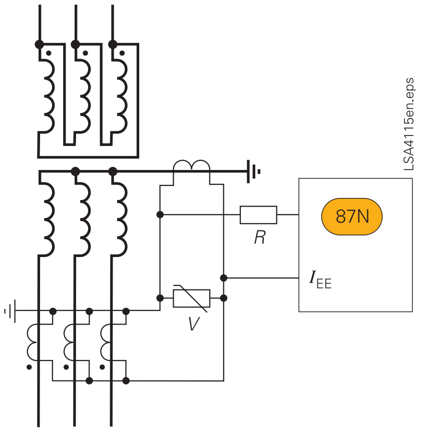


Fig. 5/154 High-impedance restricted earth-fault protection

High-impedance restricted earth-fault protection (ANSI 87N)

The high-impedance measurement principle is an uncomplicated and sensitive method for detecting earth faults, especially on transformers. It can also be applied to motors, generators and reactors when these are operated on an earthed network.

When the high-impedance measurement principle is applied, all current transformers in the protected area are connected in parallel and operated on one common resistor of relatively high *R* whose voltage is measured (see Fig. 5/154). In the case of 7SJ6 units, the voltage is measured by detecting the current through the (external) resistor *R* at the sensitive current measurement input I_{EE}. The varistor *V* serves to limit the voltage in the event of an internal fault. It cuts off the high momentary voltage spikes occurring at transformer saturation. At the same time, this results in smoothing of the voltage without any noteworthy reduction of the average value. If no faults have occurred and in the event of external faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flow through the resistor *R*.

The current transformers must be of the same type and must at least offer a separate core for the high-impedance restricted earth-fault protection. They must in particular have the same transformation ratio and an approximately identical knee-point voltage. They should also demonstrate only minimal measuring errors.

Settable dropout delay times

If the devices are used in parallel with electromechanical relays in networks with intermittent faults, the long dropout times of the electromechanical devices (several hundred milliseconds) can lead to problems in terms of time grading. Clean time grading is only possible if the dropout time is approximately the same. This is why the parameter of dropout times can be defined for certain functions such as time-overcurrent protection, earth short-circuit and phase-balance current protection.

Protection functions

Motor protection

Restart inhibit (ANSI 66/86)

If a motor is started up too many times in succession, the rotor can be subject to thermal overload, especially the upper edges of the bars. The rotor temperature is calculated from the stator current. The reclosing lockout only permits start-up of the motor if the rotor has sufficient thermal reserves for a complete start-up (see Fig. 5/155).

Emergency start-up

This function disables the reclosing lockout via a binary input by storing the state of the thermal replica as long as the binary input is active. It is also possible to reset the thermal replica to zero.

Temperature monitoring (ANSI 38)

Up to two temperature monitoring boxes with a total of 12 measuring sensors can be used for temperature monitoring and detection by the protection relay. The thermal status of motors, generators and transformers can be monitored with this device. Additionally, the temperature of the bearings of rotating machines are monitored for limit value violation. The temperatures are being measured with the help of temperature detectors at various locations of the device to be protected. This data is transmitted to the protection relay via one or two temperature monitoring boxes (see "Accessories", page 5/193).

Starting time supervision (ANSI 48/14)

Starting time supervision protects the motor against long unwanted start-ups that might occur in the event of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked. Rotor temperature is calculated from measured stator current. The tripping time is calculated according to the following equation:

for $I > I_{\mathrm{MOTOR\ START}}$

$$t = \left(\frac{I_A}{I}\right)^2 \cdot T_A$$

I = Actual current flowing

$I_{\mathrm{MOTOR\ START}}$ = Pickup current to detect a motor start

t = Tripping time

I_A = Rated motor starting current

T_A = Tripping time at rated motor starting current

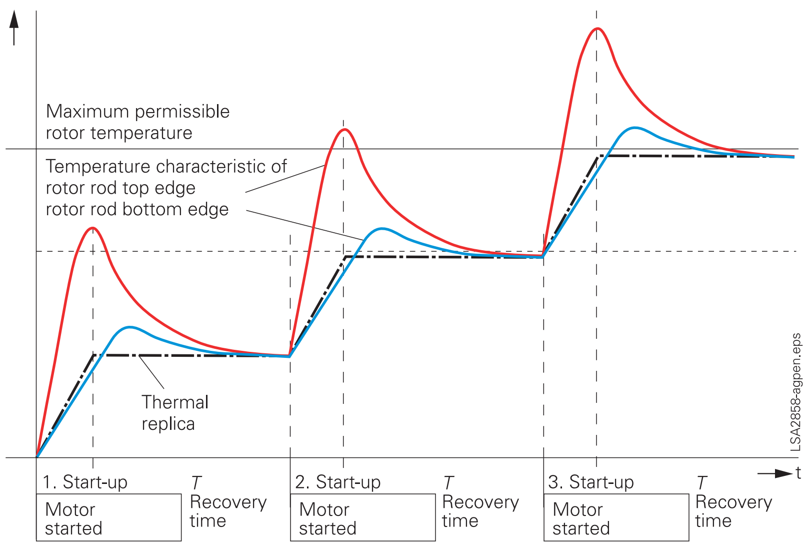


Fig. 5/155

If the trip time is rated according to the above formula, even a prolonged start-up and reduced voltage (and reduced start-up current) will be evaluated correctly. The tripping time is inverse (current dependent).

A binary signal is set by a speed sensor to detect a blocked rotor. An instantaneous tripping is effected.

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

The negative-sequence / phase-balance current protection detects a phase failure or load unbalance due to network asymmetry and protects the rotor from impermissible temperature rise.

Undercurrent monitoring (ANSI 37)

With this function, a sudden drop in current, which can occur due to a reduced motor load, is detected. This may be due to shaft breakage, no-load operation of pumps or fan failure.

Voltage protection

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase voltage (default) or with the negative phase-sequence system voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating states and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. Even when falling below this frequency range the function continues to work, however, with a greater tolerance band.

The function can operate either with the positive phase-sequence system voltage (default) or with the phase-to-phase voltages, and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for over-frequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted speed deviations. Unwanted frequency changes in the network

1) The 45 to 55, 55 to 65 Hz range is available for f_N = 50/60 Hz.

Protection functions/Functions

can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz)[1]. There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately. Blocking of the frequency protection can be performed if using a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The fault locator specifies the distance to a fault location in kilometers or miles or the reactance of a second fault operation.

Circuit-breaker wear monitoring

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no mathematically exact method of calculating the wear or the remaining service life of circuit-breakers that takes into account the arc-chamber's physical conditions when the CB opens. This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the devices offer several methods:

- ΣI
- ΣI^x, with x = 1... 3
- $\Sigma i^2 t$

The devices additionally offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 5/156) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the number of still possible switching cycles. To this end, the two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

1) The 45 to 55, 55 to 65 Hz range is available for f_N= 50/60 Hz

Commissioning

Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

■ Control and automatic functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated to the 7SJ64 via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

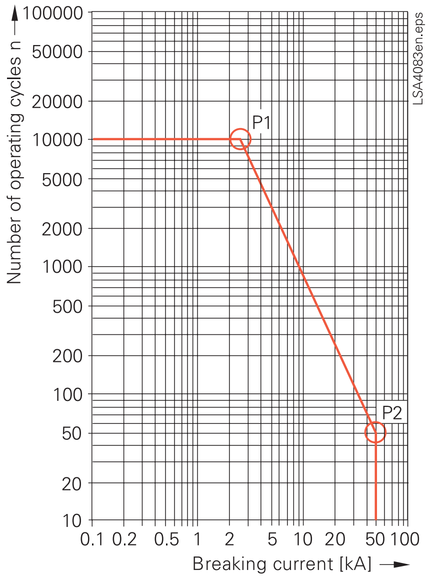


Fig. 5/156 CB switching cycle diagram

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).
If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”.

Key-operated switch

7SJ64 units are fitted with key-operated switch function for local/remote changeover and changeover between interlocked switching and test operation.

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Functions

Motor control

The SIPROTEC 4 7SJ64 with high performance relays is well-suited for direct activation of the circuit-breaker, disconnector and earthing switch operating mechanisms in automated substations.

Interlocking of the individual switching devices takes place with the aid of programmable logic. Additional auxiliary relays can be eliminated. This results in less wiring and engineering effort.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state.

Chatter disable

Chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Indication filtering and delay

Binary indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

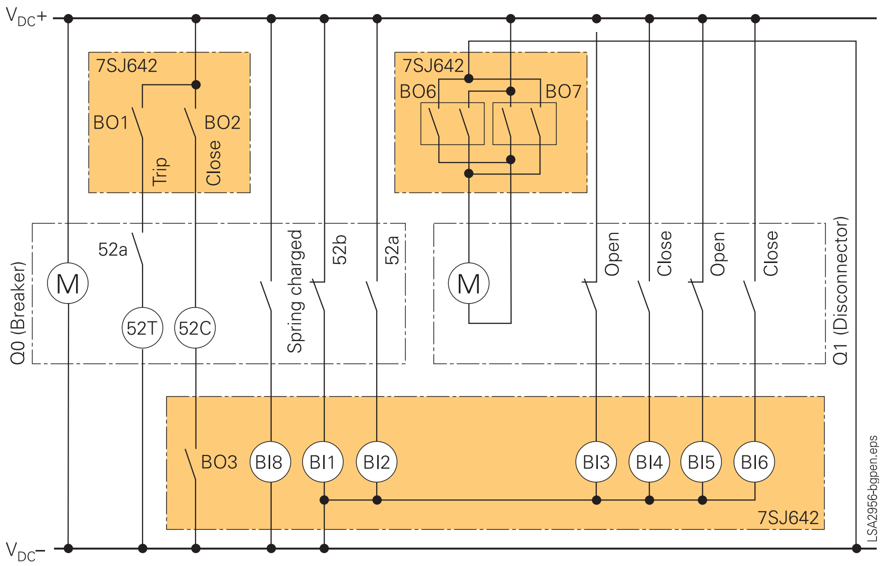


Fig. 5/157
Typical wiring for 7SJ642 motor direct control (simplified representation without fuses)
Binary output BO6 and BO7 are interlocked so that only one set of contacts are closed at a time.

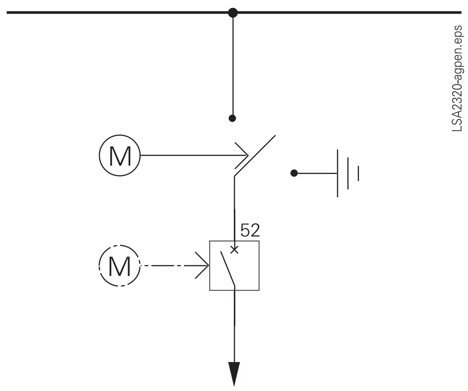


Fig. 5/158 Example: Single busbar with circuit-breaker and motor-controlled three-position switch

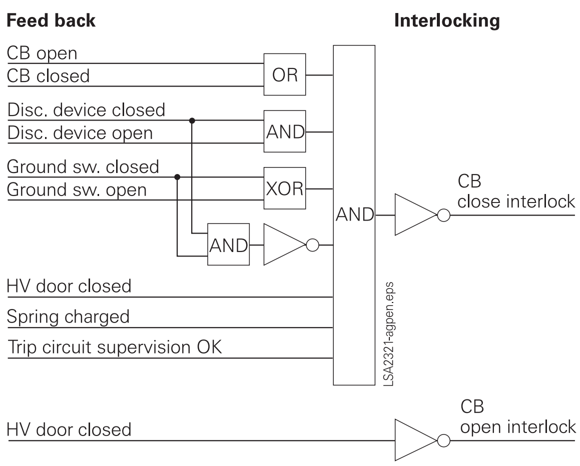


Fig. 5/159 Example: Circuit-breaker interlocking

Functions

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1}, I_{L2}, I_{L3}, I_E, I_{EE} (67Ns)
- Voltages V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}, V_{syn}
- Symmetrical components I_1, I_2, $3I_0$; V_1, V_2, V_0
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase-selective)
- Power factor (cos φ) (total and phase-selective)
- Frequency
- Energy ± kWh, ± kVArh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of overload function
- Limit value monitoring
- Limit values are monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
  In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 4 unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a control center as an accumulation with reset. A distinction is made between forward, reverse, active and reactive energy.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications.

In general, no separate measuring instruments (e.g. for current, voltage, frequency measuring transducer ...) or additional control components are necessary.

LSP2078-afp.eps

Fig. 5/160
NX PLUS panel (gas-insulated)

Communication

In terms of communication, the units offer substantial flexibility in the context of connection to industrial and power automation standards. Communication can be extended or added on thanks to modules for retrofitting on which the common protocols run. Therefore, also in the future it will be possible to optimally integrate units into the changing communication infrastructure, for example in Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Serial front interface

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Rear-mounted interfaces[1)]

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. In the flush-mounting housing, the modules can be easily replaced by the user.
The interface modules support the following applications:

- Time synchronization interface
  All units feature a permanently integrated electrical time synchronization interface. It can be used to feed timing telegrams in IRIG-B or DCF77 format into the units via time synchronization receivers.
- System interface
  Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.
- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. It can be an electrical RS232/RS485 interface. For special applications, a maximum of two temperature monitoring boxes (RTD-box) can be connected to this interface as an alternative.
- Additional interface
  Up to 2 RTD-boxes can be connected via this interface.

System interface protocols (retrofittable)

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI. It will also be possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor will also provide a few items of unit-specific information in browser windows.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized communication system (EN 50170) for efficient performance of communication tasks in the bay area. SIPROTEC 4 units use a profile specially optimized for protection and control requirements. DIGSI can also work on the basis of PROFIBUS-FMS. The units are linked to a SICAM automation system.

PROFIBUS-DP protocol

PROFIBUS-DP is the most widespread protocol in industrial automation. Via PROFIBUS-DP, SIPROTEC units make their information available to a SIMATIC controller or, in the control direction, receive commands from a central SIMATIC. Measured values can also be transferred.

MODBUS RTU protocol

This uncomplicated, serial protocol is mainly used in industry and by power supply corporations, and is supported by a number of unit manufacturers. SIPROTEC units function as MODBUS slaves, making their information available to a master or receiving information from it. A time-stamped event list is available.

1) For units in panel surface-mounting housings please refer to note on page 5/185.

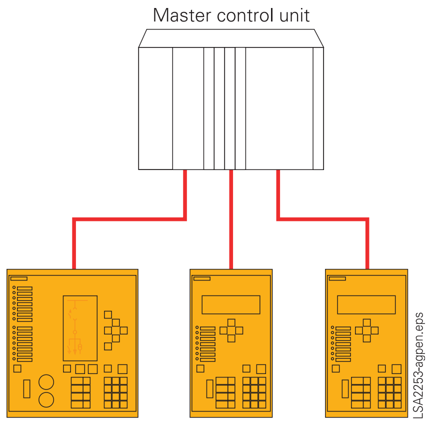


Fig. 5/161
IEC 60870-5-103: Radial fiber-optic connection

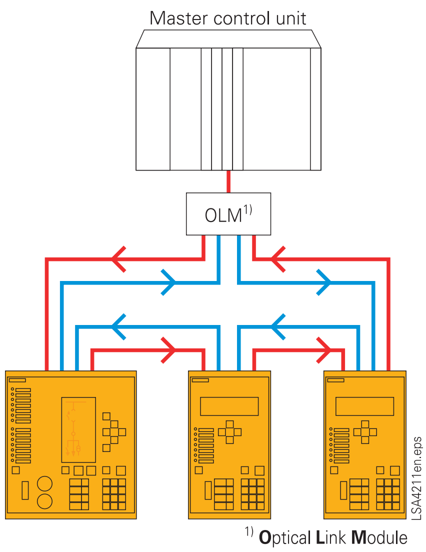


Fig. 5/162
PROFIBUS: Fiber-optic double ring circuit

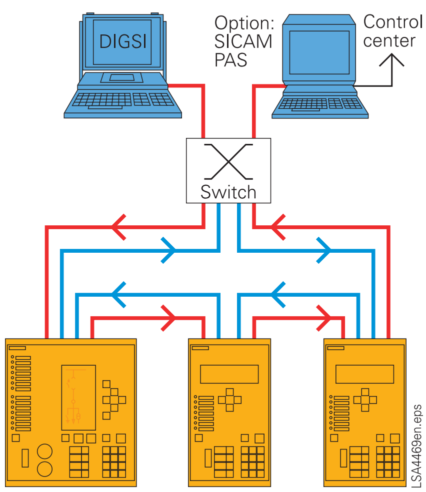


Fig. 5/163
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

Communication

DNP 3.0 protocol

Power supply corporations use the serial DNP 3.0 (Distributed Network Protocol) for the station and network control levels. SIPROTEC units function as DNP slaves, supplying their information to a master system or receiving information from it.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 5/161).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 5/163).

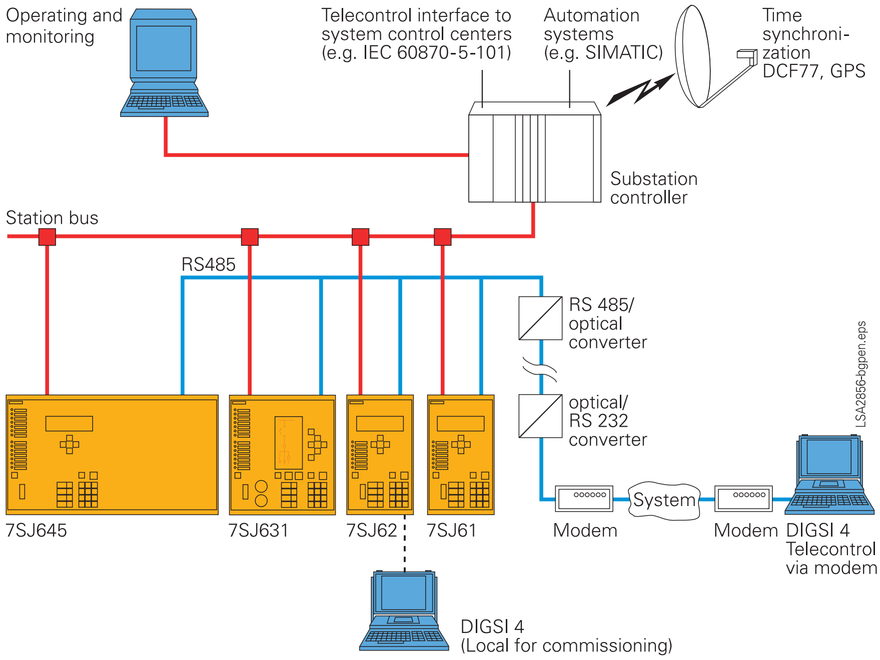


Fig. 5/164
System solution/communication

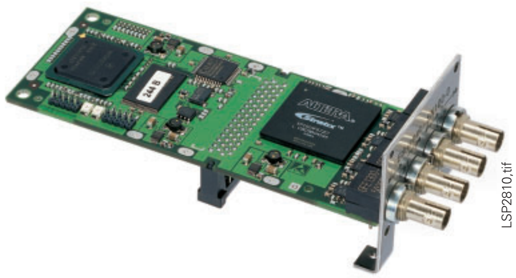


Fig. 5/165
Optical Ethernet communication module for IEC 61850 with integrated Ethernet-switch

Typical connections

Connection of current and voltage transformers

Standard connection

For earthed networks, the earth current is obtained from the phase currents by the residual current circuit.

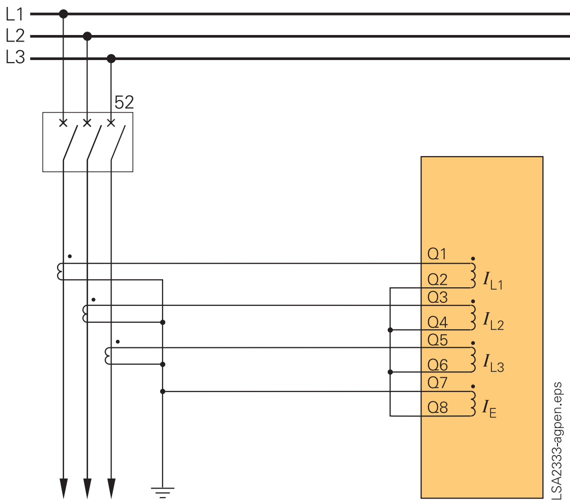


Fig. 5/166
Residual current circuit without directional element

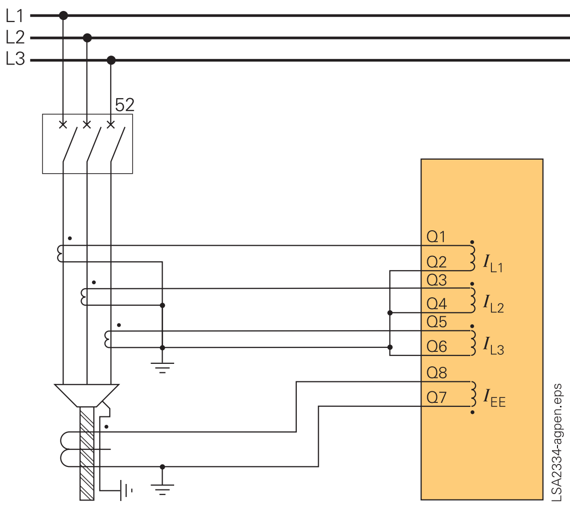


Fig. 5/167
Sensitive earth current detection without directional element

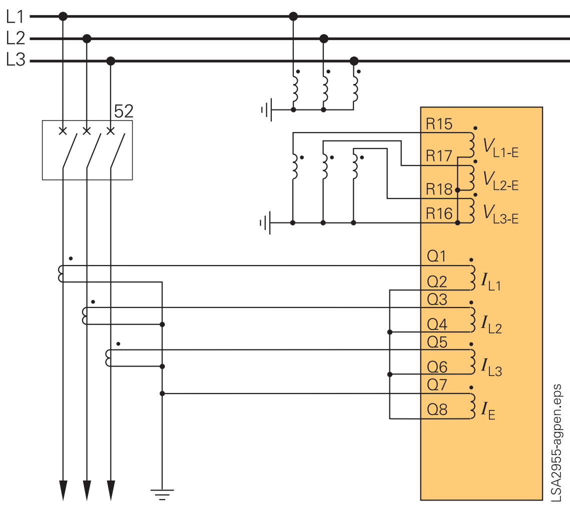


Fig. 5/168
Residual current circuit with directional element

5

Typical connections

Connection for compensated networks

The figure shows the connection of two phase-to-earth voltages and the V_E voltage of the open delta winding and a phase-earth neutral current transformer for the earth current. This connection maintains maximum precision for directional earth- fault detection and must be used in compensated networks.
Fig. 5/169 shows sensitive directional earth-fault detection.

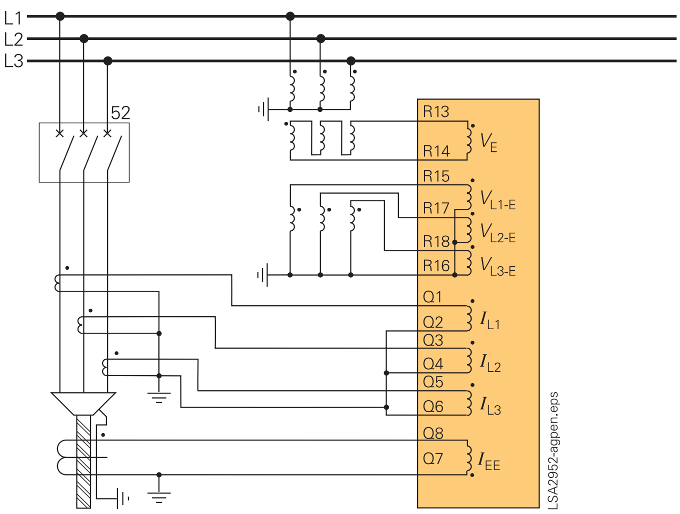


Fig. 5/169
Sensitive directional earth-fault detection with directional element for phases

Connection for isolated-neutral or compensated networks only

If directional earth-fault protection is not used, the connection can be made with only two phase current transformers. Directional phase short-circuit protection can be achieved by using only two primary transformers.

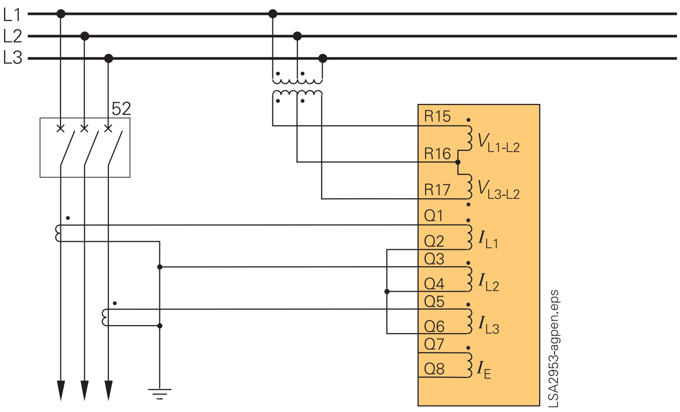


Fig. 5/170
Isolated-neutral or compensated networks

Connection for the synchronization function

The 3-phase system is connected as reference voltage, i. e. the outgoing voltages as well as a single-phase voltage, in this case a busbar voltage, that has to be synchronized.

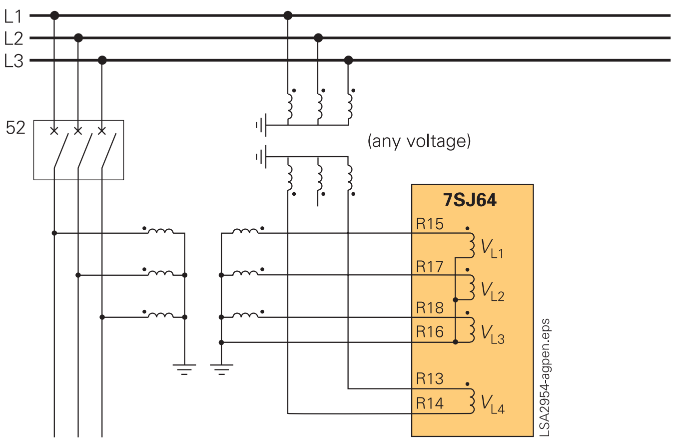


Fig. 5/171
Measuring of the busbar voltage and the outgoing feeder voltage for synchronization

Typical applications

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) earthed network	Time-overcurrent protection phase/earth non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformer possible	-
(Low-resistance) earthed networks	Sensitive earth-fault protection	Phase-balance neutral current transformers required	-
Isolated or compensated networks	Time-overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase-current transformers possible	-
(Low-resistance) earthed networks	Time-overcurrent protection phases directional	Residual circuit, with 3 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
Isolated or compensated networks	Time-overcurrent protection phases directional	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-earth connection or phase-to-phase connection
(Low-resistance) earthed networks	Time-overcurrent protection earth directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-earth connection required
Isolated networks	Sensitive earth-fault protection	Residual circuit, if earth current $> 0.05\ I_N$ on secondary side, other-wise phase-balance neutral current transformers required	3 times phase-to-earth connection or phase-to-earth connection with open delta winding
Compensated networks	Sensitive earth-fault protection cos φ measurement	Phase-balance neutral current transformers required	Phase-to-earth connection with open delta winding required

■ Application examples

Synchronization function

When two subnetworks must be interconnected, the synchronization function monitors whether the subnetworks are synchronous and can be connected without risk of losing stability.

As shown in Fig. 5/172, load is being fed from a generator to a busbar via a transformer. It is assumed that the frequency difference of the 2 subnetworks is such that the device determines asynchronous system conditions.

The voltages of the busbar and the feeder should be the same when the contacts are made; to ensure this condition the synchronism function must run in the “synchronous/asynchronous switching” mode.
In this mode, the operating time of the CB can be set within the relay.
Differences between angle and frequency can then be calculated by the relay while taking into account the operating time of the CB.
From these differences, the unit derives the exact time for issuing the CLOSE command under asynchronous conditions.
When the contacts close, the voltages will be in phase.

The vector group of the transformer can be considered by setting parameters. Thus no external circuits for vector group adaptation are required.

This synchronism function can be applied in conjunction with the auto-reclosure function as well as with the control function CLOSE commands (local/remote).

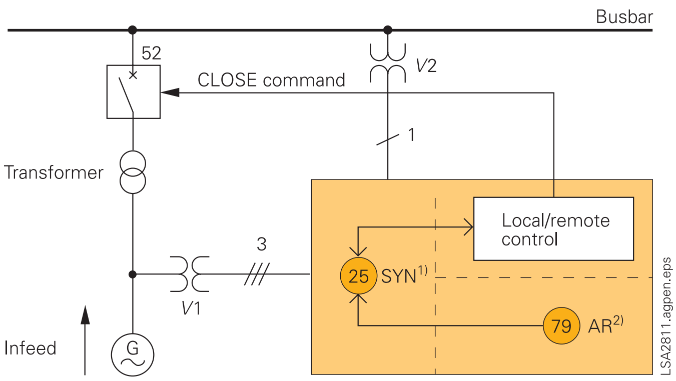


Fig. 5/172

1) Synchronization function
2) Auto-reclosure function

Typical applications

Connection of circuit-breaker

Undervoltage releases

Undervoltage releases are used for automatic tripping of high-voltage motors.

Example:
DC supply voltage of control system fails and manual electric tripping is no longer possible.

Automatic tripping takes place when voltage across the coil drops below the trip limit. In Figure 5/173, tripping occurs due to failure of DC supply voltage, by automatic opening of the live status contact upon failure of the protection unit or by short-circuiting the trip coil in event of a network fault.

In Fig. 5/174 tripping is by failure of auxiliary voltage and by interruption of tripping circuit in the event of network failure. Upon failure of the protection unit, the tripping circuit is also interrupted, since contact held by internal logic drops back into open position.

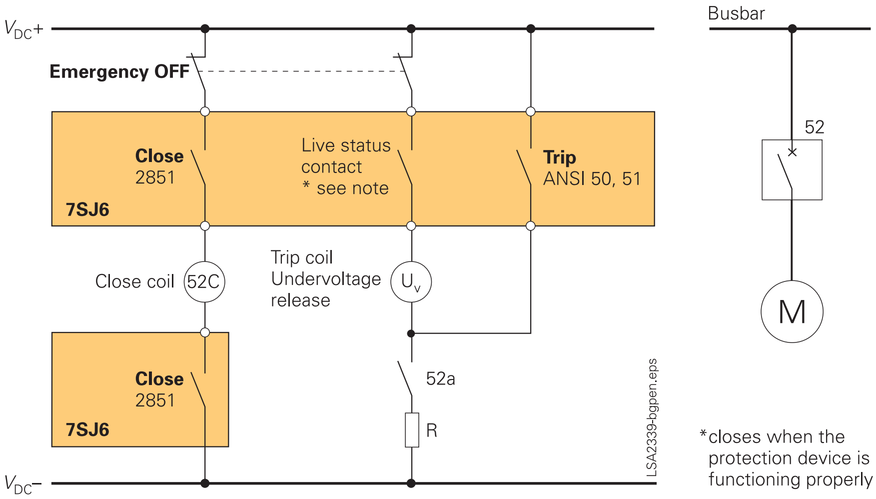


Fig. 5/173 Undervoltage release with make contact 50, 51

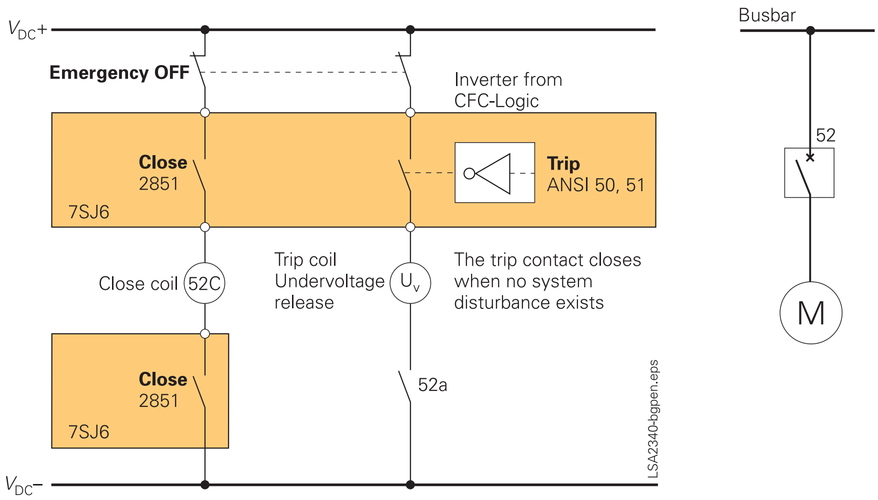


Fig. 5/174 Undervoltage release with locking contact (trip signal 50 is inverted)

5

Typical applications

Trip circuit supervision (ANSI 74TC)

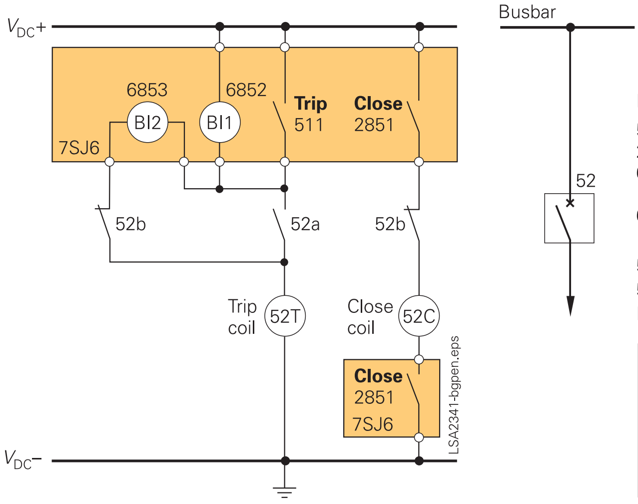
One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Reverse-power protection for dual supply (ANSI 32R)

If power is fed to a busbar through two parallel infeeds, then in the event of any fault on one of the infeeds it should be selectively interrupted. This ensures a continued supply to the busbar through the remaining infeed. For this purpose, directional devices are needed which detect a short-circuit current or a power flow from the busbar in the direction of the infeed. The directional time-overcurrent protection is usually set via the load current. It cannot be used to deactivate low-current faults. Reverse-power protection can be set far below the rated power. This ensures that it also detects power feedback into the line in the event of low-current faults with levels far below the load current. Reverse-power protection is performed via the "flexible protection functions" of the 7SJ64.



TRIP contact	Breaker	BI1	BI2
open	closed	H	L
open	open	H	H
closed	closed	L	L
closed	open	L	H

Fig. 5/175 Trip circuit supervision with 2 binary inputs

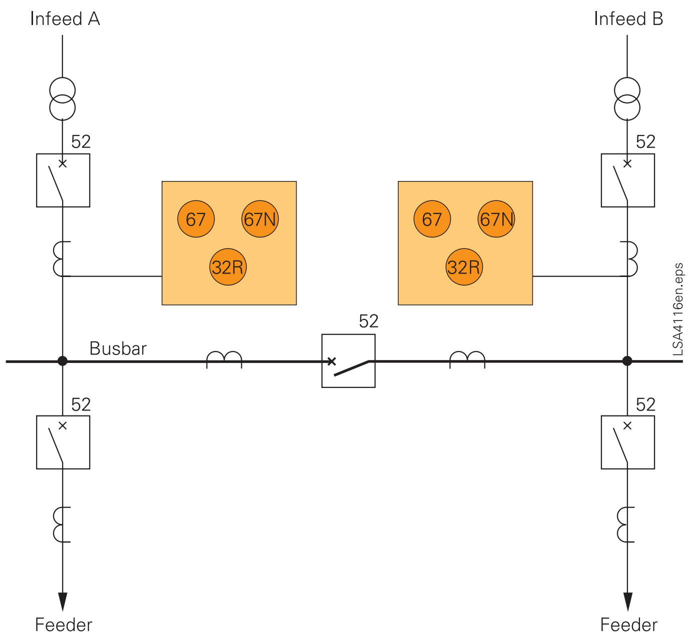


Fig. 5/176 Reverse-power protection for dual supply

Technical data

General unit data			
Measuring circuits			
System frequency	50 / 60 Hz (settable)		
Current transformer			
Rated current I_{nom}	1 or 5 A (settable)		
Option: sensitive earth-fault CT	I_{EE} < 1.6 A		
Power consumption at I_{nom} = 1 A at I_{nom} = 5 A for sensitive earth-fault CT at 1 A	 Approx. 0.05 VA per phase Approx. 0.3 VA per phase Approx. 0.05 VA		
Overload capability Thermal (effective) Dynamic (impulse current)	 100 x I_{nom} for 1 s 30 x I_{nom} for 10 s 4 x I_{nom} continuous 250 x I_{nom} (half cycle)		
Overload capability if equipped with sensitive earth-fault CT Thermal (effective) Dynamic (impulse current)	 300 A for 1 s 100 A for 10 s 15 A continuous 750 A (half cycle)		
Voltage transformer			
Rated voltage V_{nom}	100 V to 225 V		
Power consumption at V_{nom} = 100 V	< 0.3 VA per phase		
Overload capability in voltage path (phase-neutral voltage) Thermal (effective)	 230 V continuous		
Auxiliary voltage *(via integrated converter)*			
Rated auxiliary voltage V_{aux} DC	24/48 V	60/125 V	110/250 V
Permissible tolerance DC	19 - 58 V	48 - 150 V	88 - 300 V
Ripple voltage, peak-to-peak	≤ 12 % of rated auxiliary voltage		
Power consumption	7SJ640	7SJ641 7SJ642	7SJ645
Quiescent Approx. Energized Approx.	5 W 7.5 W	5 W 12 W	5 W 16 W
Backup time during loss/short-circuit of auxiliary direct voltage	≥ 50 ms at V > 110 V DC ≥ 20 ms at V > 24 V DC		
Rated auxiliary voltage V_{aux} AC	115 / 230 V		
Permissible tolerance AC	92 - 132 V / 184 - 265 V		
Power consumption	7SJ640	7SJ641 7SJ642	7SJ645
Quiescent Approx. Energized Approx.	6.5 W 12.5 W	6.5 W 16.5 W	6.5 W 21 W
Backup time during loss/short-circuit of auxiliary alternating voltage	≥ 200 ms		

Binary inputs/indication inputs				
Type	7SJ640	7SJ641	7SJ642	7SJ645
Number (marshallable)	7	15	20	33
Voltage range	24 - 250 V DC			
Pickup threshold modifiable by plug-in jumpers				
Pickup threshold DC	19 V DC		88 V DC	
For rated control voltage DC	24/48/60/110/ 125 V DC		110/125/220/250 V DC	
Power consumption energized	0.9 mA (independent of operating voltage) for BI 8…19 / 21…32; 1.8 mA for BI 1…7 / 20/33			
Binary outputs/command outputs				
Type	7SJ640	7SJ641	7SJ642	7SJ645
Command/indication relay	5	13	8	11
Contacts per command/ indication relay	1 NO / form A			
Live status contact	1 NO / NC (jumper)/form A/B			
Switching capacity Make	1000 W / VA			
Break	30 W / VA / 40 W resistive / 25 W at L/R ≤ 50 ms			
Switching voltage	≤ 250 V DC			
Permissible current	5 A continuous, 30 A for 0.5 s making current, 2000 switching cycles			
Power relay *(for motor control)*				
Type	7SJ640 7SJ641	7SJ642	7SJ645	
Number	0	2 (4)	4 (8)	
Number of contacts/relay		2 NO / form A		
Switching capacity Make	1000 W / VA at 48 V … 250 V / 500 W at 24 V			
Break	1000 W / VA at 48 V … 250 V / 500 W at 24 V			
Switching voltage	≤ 250 V DC			
Permissible current	5 A continuous, 30 A for 0.5 s			

5

Technical data

Electrical tests	
Specification	
Standards	IEC 60255 ANSI C37.90, C37.90.1, C37.90.2, UL508
Insulation tests	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Voltage test (100 % test) all circuits except for auxiliary voltage and RS485/RS232 and time synchronization	2.5 kV (r.m.s. value), 50/60 Hz
Auxiliary voltage	3.5 kV DC
Communication ports and time synchronization	500 V AC
Impulse voltage test (type test) all circuits, except communication ports and time synchronization, class III	5 kV (peak value); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
***EMC tests for interference immunity;** type tests*	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 50082-2 (generic specification) DIN 57435 Part 303
High-frequency test IEC 60255-22-1, class III and VDE 0435 Part 303, class III	2.5 kV (peak value); 1 MHz; τ =15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air gap discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (Report) class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3; class III	10 V/m, 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, on duration 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge) IEC 61000-4-5; class III	
Auxiliary voltage	From circuit to circuit: 2 kV; 12 Ω; 9 µF across contacts: 1 kV; 2 Ω ;18 µF
Binary inputs/outputs	From circuit to circuit: 2 kV; 42 Ω; 0.5 µF across contacts: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV IEC 60255-6	30 A/m; 50 Hz, continuous 300 A/m; 50 Hz, 3 s 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value), 1 to 1.5 MHz damped wave; 50 surges per s; duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s both polarities; duration 2 s, R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
Damped wave IEC 60694 / IEC 61000-4-12	2.5 kV (peak value, polarity alternating) 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
***EMC tests for interference emission;** type tests*	
Standard	EN 50081-* (generic specification)
Conducted interferences only auxiliary voltage IEC/CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC/CISPR 11	30 to 1000 MHz Limit class B
Units with a detached operator panel must be installed in a metal cubicle to maintain limit class B	

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz; +/- 0.075 mm amplitude; 60 to 150 Hz; 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms; 3 shocks in both directions of 3 axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 perpendicular axes
<u>During transportation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz; 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 perpendicular axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms 3 shocks in both directions of 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms 1000 shocks in both directions of 3 axes

Technical data

Climatic stress tests

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C /-13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C /-4 °F to -158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C /+131 °F)	-5 °C to +55 °C /+25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C /-13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C /-13 °F to +158 °F

Humidity

Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 95 % relative humidity; condensation not permissible!

Unit design

Type	7SJ640	7SJ641 7SJ642	7SJ645
Housing	7XP20		
Dimensions	See dimension drawings, part 16 of this catalog		
Weight in kg	Housing width 1/3	Housing width 1/2	Housing width 1/1
Surface-mounting housing	8	11	15
Flush-mounting housing	5	6	10
Housing for detached operator panel	–	8	12
Detached operator panel	–	2.5	2.5
Degree of protection acc. to EN 60529			
Surface-mounting housing	IP 51		
Flush-mounting housing	Front: IP 51, rear: IP 20;		
Operator safety	IP 2x with cover		

Serial interfaces

Operating interface *(front of unit)*

Connection	Non-isolated, RS232; front panel, 9-pin subminiature connector
Transmission rate	min. 4800 baud, max. 115200 baud

Service/modem interface *(rear of unit)*

Isolated interface for data transfer	Port C: DIGSI 4/modem/RTD-box
Transmission rate	Setting as supplied 38400 baud min. 4800 baud, max. 115200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "C"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	15 m /49.2 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth

Additional interface *(rear of unit)*

Isolated interface for data transfer	Port D: RTD-box
Transmission rate	Setting as supplied 38400 baud min. 4800 baud, max. 115200 baud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "D"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "D"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles

5

Technical data

System interface *(rear of unit)*	
IEC 60870-5-103 protocol	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Setting as supplied: 9600 baud, min. 9600 baud, max. 19200 baud
RS232/RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance RS232	Max. 15 m/49 ft
Distance RS485	Max. 1 km/3300 ft
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable	Integrated ST connector for fi-ber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
IEC 61850 protocol	
Isolated interface for data transfer: - to a control center - with DIGSI - between SIPROTEC 4 relays	Port B, 100 Base T acc. to IEEE802.3
Transmission rate	100 Mbit
Ethernet, electrical	
Connection For flush-mounting housing/ surface-mounting housing with detached operator panel	Two RJ45 connectors Mounting location "B"
Distance	Max. 20 m / 65.6 ft
Test voltage	500 V AC against earth
Ethernet, optical	
Connection	Intergr. ST connector for FO connec-tion
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
Optical wavelength	1300 nmm
Distance	1.5 km/0.9 miles
PROFIBUS-FMS/DP	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 1.5 Mbaud

RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing: shielded data cable
Distance	1000 m/3300 ft ≤ 93.75 kbaud; 500 m/1500 ft ≤ 187.5 kbaud; 200 m/600 ft ≤ 1.5 Mbaud 100 m/300 ft ≤ 12 Mbaud
Test voltage	500 V AC against earth
Fiber optic	
Connection fiber-optic cable For flush-mounting housing/ surface-mounting housing with detached operator panel	Integr. ST connector for FO connec-tion, mounting location "B"
For surface-mounting housing with two-tier terminal on the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/189
Optical wavelength	820 nm
Permissible path attenuation	Max. 8 dB, for glass fiber 62.5/125 µm
Distance	500 kB/s 1.6 km/0.99 miles 1500 kB/s 530 m/0.33 miles
MODBUS RTU, ASCII, DNP 3.0	
Isolated interface for data transfer to a control center	Port B
Transmission rate	Up to 19200 baud
RS485	
Connection	
For flush-mounting housing/ surface-mounting housing with detached operator panel	9-pin subminiature connector, mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At bottom part of the housing: shielded data cable
Distance	Max. 1 km/3300 ft max. 32 units recommended
Test voltage	500 V AC against earth
Fiber-optic	
Connection fiber-optic cable	Integrated ST connector for fiber-optic connection
For flush-mounting housing/ surface-mounting housing with detached operator panel	Mounting location "B"
For surface-mounting housing with two-tier terminal at the top/bottom part	At the bottom part of the housing Important: Please refer to footnotes 1) and 2) on page 5/189
Optical wavelength	820 nm
Permissible path attenuation	Max 8 dB. for glass fiber 62.5/125 µm
Distance	Max. 1.5 km/0.9 miles
Time synchronization DCF77/IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

1) At I_{nom} = 1 A, all limits divided by 5.

5

Technical data

Functions	
Definite-time overcurrent protection, directional/non-directional *(ANSI 50, 50N, 67, 67N)*	
Operating mode non-directional phase protection (ANSI 50)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase elements $I>$, $I>>$	0.5 to 175 A or ∞ [1] (in steps of 0.01 A)
Pickup earth elements $I_E>$, $I_E>>$	0.25 to 175 A or ∞ [1] (in steps of 0.01 A)
Delay times T	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times Pickup times (without inrush restraint, with inrush restraint + 10 ms)	
	Non-directional / Directional
With twice the setting value	Approx. 30 ms / 45 ms
With five times the setting value	Approx. 20 ms / 40 ms
Dropout times	Approx. 40 ms
Dropout ratio	Approx. 0.95 for $I/I_{nom} \geq 0.3$
Tolerances	
Pickup	2 % of setting value or 50 mA [1]
Delay times T, T_{DO}	1 % or 10 ms
Inverse-time overcurrent protection, directional/non-directional *(ANSI 51, 51N, 67, 67N)*	
Operating mode non-directional phase protection (ANSI 51)	3-phase (standard) or 2-phase (L1 and L3)
Setting ranges	
Pickup phase element I_P	0.5 to 20 A or ∞ [1] (in steps of 0.01 A)
Pickup earth element I_{EP}	0.25 to 20 A or ∞ [1] (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.05 to 15 s or ∞ (in steps of 0.01 s)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse, long inverse
ANSI	Inverse, short inverse, long inverse moderately inverse, very inverse, extremely inverse, definite inverse
User-defined characteristic	Defined by a maximum of 20 value pairs of current and time delay
Dropout setting	
Without disk emulation	Approx. 1.05 · setting value I_p for $I_p/I_{nom} \geq 0.3$, corresponds to approx. 0.95 · pickup threshold
With disk emulation	Approx. 0.90 · setting value I_p
Tolerances	
Pickup/dropout thresholds I_p, I_{Ep}	2 % of setting value or 50 mA [1]
Pickup time for $2 \leq I/I_p \leq 20$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms
Dropout ratio for $0.05 \leq I/I_p \leq 0.9$	5 % of reference (calculated) value + 2 % current tolerance, respectively 30 ms

1) At I_{nom} = 1 A, all limits divided by 5.

Direction detection	
For phase faults	
Polarization	With cross-polarized voltages; With voltage memory for measurement voltages that are too low
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	For one and two-phase faults unlimited; For three-phase faults dynamically unlimited; Steady-state approx. 7 V phase-to-phase
For earth faults	
Polarization	With zero-sequence quantities $3V_0$, $3I_0$ or with negative-sequence quantities $3V_2$, $3I_2$
Forward range	$V_{ref,rot} \pm 86°$
Rotation of reference voltage $V_{ref,rot}$	- 180° to 180° (in steps of 1°)
Direction sensitivity	
Zero-sequence quantities $3V_0$, $3I_0$	$V_E \approx 2.5$ V displacement voltage, measured; $3V_0 \approx 5$ V displacement voltage, calculated
Negative -sequence quantities $3V_2$, $3I_2$	$3V_2 \approx 5$ V negative-sequence voltage; $3I_2 \approx 225$ mA negative-sequence current [1]
Tolerances (phase angle error under reference conditions)	
For phase and earth faults	± 3 ° electrical
Inrush blocking	
Influenced functions	Time-overcurrent elements, $I>$, $I_E>$, I_p, I_{Ep} (directional, non-directional)
Lower function limit	1.25 A [1]
Upper function limit (setting range)	1.5 to 125 A [1] (in steps of 0.01 A)
Setting range I_{2f}/I	10 to 45 % (in steps of 1 %)
Crossblock (I_{L1}, I_{L2}, I_{L3})	ON/OFF
Dynamic setting change	
Controllable function	Directional and non-directional pickup, tripping time
Start criteria	Current criteria, CB position via aux. contacts, binary input, auto-reclosure ready
Time control	3 timers
Current criteria	Current threshold (reset on dropping below threshold; monitoring with timer)

Technical data

(Sensitive) earth-fault detection *(ANSI 64, 50 Ns, 51Ns, 67Ns)*	
Displacement voltage starting *for all types of earth fault (ANSI 64)*	
Setting ranges	
Pickup threshold V_E> (measured)	1.8 to 200 V (in steps of 0.1 V)
Pickup threshold $3V_0$> (calculated)	10 to 225 V (in steps of 0.1 V)
Delay time $T_{\text{Delay pickup}}$	0.04 to 320 s or ∞ (in steps of 0.01 s)
Additional trip delay T_{VDELAY}	0.1 to 40000 s or ∞ (in steps of 0.01 s)
Times	
Pickup time	Approx. 60 ms
Dropout ratio	0.95 or (pickup value -0.6 V)
Tolerances	
Pickup threshold V_E (measured)	3 % of setting value or 0.3 V
Pickup threshold $3V_0$ (calculated)	3 % of setting value or 3 V
Delay times	1 % of setting value or 10 ms
Phase detection for earth fault in an unearthed system	
Measuring principle	Voltage measurement (phase-to-earth)
Setting ranges	
$V_{\text{ph min}}$ (earth-fault phase)	10 to 100 V (in steps of 1 V)
$V_{\text{ph max}}$ (unfaulted phases)	10 to 100 V (in steps of 1 V)
Measuring tolerance acc. to DIN 57435 part 303	3 % of setting value, or 1 V
Earth-fault pickup *for all types of earth faults*	
Definite-time characteristic *(ANSI 50Ns)*	
Setting ranges	
Pickup threshold I_{EE}>, I_{EE}>>	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
Delay times T for I_{EE}>, I_{EE}>>	0 to 320 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Times	
Pickup times	Approx. 60 ms (non-directional) Approx. 80 ms (directional
Dropout ratio	Approx. 0.95
Tolerances	
Pickup threshold I_{EE}>, I_{EE}>>	2 % of setting value or 1 mA
Delay times	1 % of setting value or 20 ms
Earth-fault pickup *for all types of earth faults*	
Inverse-time characteristic *(ANSI 51Ns)*	
User-defined characteristic	Defined by a maximum of 20 pairs of current and delay time values
Logarithmic inverse	$t = T_{\text{IEEpmax}} - T_{\text{IEEp}} \cdot \ln \frac{I}{I_{\text{EEp}}}$
Setting ranges	
Pickup threshold I_{EEp}	
For sensitive input	0.001 A to 1.4 A (in steps of 0.001 A)
For normal input	0.25 to 20 A[1)] (in steps of 0.01 A)
User defined	
Time multiplier T	0.1 to 4 s or ∞ (in steps of 0.01 s)
Logarithmic inverse	
Time multiplier $T_{\text{IEEp mul}}$	0.05 to 15 s or ∞ (in steps of 0.01 s)
Delay time T_{IEEp}	0.1 to 4 s or ∞ (in steps of 0.01 s)
Min time delay T_{IEEpmin}	0 to 32 s (in steps of 0.01 s)
Max. time delay T_{IEEpmax}	0 to 32 s (in steps of 0.01 s)

Note: Due to the high sensitivity the linear range of the measuring input IN with integrated sensitive input transformer is from 0.001 A to 1.6 A. For currents greater than 1.6 A, correct directionality can no longer be guaranteed.

1) For I_{nom} = 1 A, all limits divided by 5.

Times	
Pickup times	Approx. 60 ms (non-directional) Approx 80 ms (directional)
Pickup threshold	Approx. 1.1 · I_{EEp}
Dropout ratio	Approx. 1.05 · I_{EEp}
Tolerances	
Pickup threshold I_{EEp}	2 % of setting value or 1 mA
Delay times in linear range	7 % of reference value for 2 ≤ I/I_{EEp} ≤ 20 + 2 % current tolerance, or 70 ms
Direction detection *for all types of earth-faults (ANSI 67Ns)*	
Direction measurement	I_E and V_E measured or $3I_0$ and $3V_0$ calculated
Measuring principle	Active/reactive power measurement
Setting ranges	
Measuring enable $I_{\text{Release direct.}}$	
For sensitive input	0.001 to 1.2 A (in steps of 0.001 A)
For normal input	0.25 to 150 A[1)] (in steps of 0.01 A)
Measuring method	cos φ and sin φ
Direction phasor $\varphi_{\text{Correction}}$	- 45 ° to + 45 ° (in steps of 0.1 °)
Dropout delay $T_{\text{Reset delay}}$	1 to 60 s (in steps of 1 s)
Angle correction for cable CT	
Angle correction F1, F2	0 ° to 5 ° (in steps of 0.1 °)
Current value $I1$, $I2$	
For sensitive input	0.001 to 1.5 A (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] (in steps of 0.01 A)
Tolerances	
Pickup measuring enable	2 % of the setting value or 1 mA
Angle tolerance	3 °
High-impedance restricted earth-fault protection *(ANSI 87N) / single-phase overcurrent protection*	
Setting ranges	
Pickup thresholds I>, I>>	
For sensitive input	0.003 to 1.5 A or ∞ (in steps of 0.001 A)
For normal input	0.25 to 175 A[1)] or ∞ (in steps of 0.01 A)
Delay times T_I>, T_I>>	0 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
Minimum	Approx. 20 ms
Typical	Approx. 30 ms
Dropout times	Approx. 30 ms
Dropout ratio	Approx. 0.95 for $I/I_{\text{nom}} \geq 0.5$
Tolerances	
Pickup thresholds	3 % of setting value or 1 % rated current at I_{nom} = 1 or 5 A; 5 % of setting value or 3 % rated current at I_{nom} = 0.1 A
Delay times	1 % of setting value or 10 ms
Intermittent earth-fault protection	
Setting ranges	
Pickup threshold	
For I_E — I_{IE}>	0.25 to 175 A[1)] (in steps of 0.01 A)
For $3I_0$ — I_{IE}>	0.25 to 175 A[1)] (in steps of 0.01 A)
For I_{EE} — I_{IE}>	0.005 to 1.5 A (in steps of 0.001 A)
Pickup prolongation time — T_V	0 to 10 s (in steps of 0.01 s)
Earth-fault accumulation time — T_{sum}	0 to 100 s (in steps of 0.01 s)
Reset time for accumulation — T_{res}	1 to 600 s (in steps of 1 s)
Number of pickups for intermittent earth fault	2 to 10 (in steps of 1)

5

Technical data

Times	
Pickup times	
Current = 1.25 · pickup value	Approx. 30 ms
Current ≥ 2 · pickup value	Approx. 22 ms
Dropout time	Approx. 22 ms
Tolerances	
Pickup threshold I_{IE}>	3 % of setting value, or 50 mA [1)]
Times T_V, T_{sum}, T_{res}	1 % of setting value or 10 ms
Thermal overload protection *(ANSI 49)*	
Setting ranges	
Factor k	0.1 to 4 (in steps of 0.01)
Time constant	1 to 999.9 min (in steps of 0.1 min)
Warning overtemperature $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % with reference to the tripping overtemperature (in steps of 1 %)
Current warning stage I_{alarm}	0.5 to 20 A (in steps of 0.01 A)
Extension factor when stopped k_τ factor	1 to 10 with reference to the time constant with the machine running (in steps of 0.1)
Rated overtemperature (for I_{nom})	40 to 200 °C (in steps of 1 °C)
Tripping characteristic For $(I/k \cdot I_{nom}) \leq 8$	$t = \tau_{th} \cdot \ln \dfrac{(I/k \cdot I_{nom})^2 - (I_{pre}/k \cdot I_{nom})^2}{(I/k \cdot I_{nom})^2 - 1}$ t = Tripping time τ_{th} = Temperature rise time constant I = Load current I_{pre} = Preload current k = Setting factor acc. to VDE 0435 Part 3011 and IEC 60255-8 I_{nom} = Rated (nominal) current of the protection relay
Dropout ratios	
Θ/Θ_{Trip}	Drops out with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.97
Tolerances	
With reference to k · I_{nom}	Class 5 acc. to IEC 60255-8
With reference to tripping time	5 % +/- 2 s acc. to IEC 60255-8
Auto-reclosure *(ANSI 79)*	
Number of reclosures	0 to 9 Shot 1 to 4 individually adjustable
Program for phase fault Start-up by	Time-overcurrent elements (dir., non-dir.), negative sequence, binary input
Program for earth fault Start-up by	Time-overcurrent elements (dir., non-dir.), sensitive earth-fault protection, binary input
Blocking of ARC	Pickup of protection functions, three-phase fault detected by a protective element, binary input, last TRIP command after the reclosing cycle is complete (unsuccessful reclosing), TRIP command by the breaker failure protection (50BF), opening the CB without ARC initiation, external CLOSE command

1) At I_{nom} = 1 A, all limits divided by 5.

Setting ranges	
Dead time (separate for phase and earth and individual for shots 1 to 4)	0.01 to 320 s (in steps of 0.01 s)
Blocking duration for manual-CLOSE detection	0.5 s to 320 s or 0 (in steps of 0.01 s)
Blocking duration after reclosure	0.5 s to 320 s (in steps of 0.01 s)
Blocking duration after dynamic blocking	0.01 to 320 s (in steps of 0.01 s)
Start-signal monitoring time	0.01 to 320 s or ∞ (in steps of 0.01 s)
Circuit-breaker supervision time	0.1 to 320 s (in steps of 0.01 s)
Max. delay of dead-time start	0 to 1800 s or ∞ (in steps of 0.1 s)
Maximum dead time extension	0.5 to 320 s or ∞(in steps of 0.01 s)
Action time	0.01 to 320 s or ∞ (in steps of 0.01 s)

The delay times of the following protection function can be altered individually by the ARC for shots 1 to 4 (setting value $T = T$, non-delayed $T = 0$, blocking $T = \infty$):
I>>, I>, I_p, I_{dir}>>, I_{dir}>, I_{pdir}
I_E>>, I_E>, I_{Ep}, I_{Edir}>>, I_{Edir}>, I_{Edir}

Additional functions	Lockout (final trip), delay of dead-time start via binary input (monitored), dead-time extension via binary input (monitored), co-ordination with other protection relays, circuit-breaker monitoring, evaluation of the CB contacts
Breaker failure protection *(ANSI 50 BF)*	
Setting ranges	
Pickup threshold CB I>	0.2 to 5 A [1)] (in steps of 0.01 A)
Delay time	0.06 to 60 s or ∞ (in steps of 0.01 s)
Times	
Pickup times	
with internal start	is contained in the delay time
start via control	is contained in the delay time
with external start	is contained in the delay time
Dropout times	Approx. 25 ms
Tolerances	
Pickup value	2 % of setting value (50 mA) [1)]
Delay time	1 % or 20 ms
Synchro- and voltage check *(ANSI 25)*	
Operating modes	• Synchro-check • Asynchronous/synchronous
Additional release conditions	• Live-bus / dead line • Dead-bus / live-line • Dead-bus and dead-line • Bypassing
Voltages	
Max. operating voltage V_{max}	20 to 140 V (phase-to-phase) (in steps of 1 V)
Min. operating voltage V_{min}	20 to 125 V (phase-to-phase) (in steps of 1 V)
V< for dead-line / dead-bus check	1 to 60 V (phase-to-phase) (in steps of 1 V)
V> for live-line / live-bus check	20 to 140 V (phase-to-phase) (in steps of 1 V)
Primary rated voltage of transformer $V2_{nom}$	0.1 to 800 kV (in steps of 0.01 kV)
Tolerances	2 % of pickup value or 2 V
Drop-off to pickup ratios	approx. 0.9 (V>) or 1.1 (V<)

Technical data

ΔV-measurement	
Voltage difference	0.5 to 50 V (phase-to-phase) (in steps of 1 V)
Tolerance	1 V
Δf-measurement	
Δf-measurement ($f2>f1$; $f2<f1$)	0.01 to 2 Hz (in steps of 0.01 Hz)
Tolerance	15 mHz
$\Delta\alpha$-measurement	
$\Delta\alpha$-measurement ($\alpha2>\alpha1$; $\alpha2>\alpha1$)	2 ° to 80 ° (in steps of 1 °)
Tolerance	2 °
Max. phase displacement	5 ° for $\Delta f \leq 1$ Hz 10 ° for $\Delta f > 1$ Hz
Circuit-breaker operating time	
CB operating time	0.01 to 0.6 s (in steps of 0.01 s)
Threshold ASYN ⇔ SYN	
Threshold synchronous / asynchronous	0.01 to 0.04 Hz (in steps of 0.01 Hz)
Adaptation	
Vector group adaptation by angle	0 ° to 360 ° (in steps of 1 °)
Different voltage transformers V_1/V_2	0.5 to 2 (in steps of 0.01)
Times	
Minimum measuring time	Approx. 80 ms
Max. duration $T_{\text{SYN DURATION}}$	0.01 to 1200 s; ∞ (in steps of 0.01 s)
Supervision time $T_{\text{SUP VOLTAGE}}$	0 to 60 s (in steps of 0.01 s)
Closing time of CB $T_{\text{CB close}}$	0 to 60 s (in steps of 0.01 s)
Tolerance of all timers	1 % of setting value or 10 ms
Measuring values of synchronization function	
Reference voltage $V1$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Voltage to be synchronized $V2$	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Frequency of $V1$ and $V2$	$f1$, $f2$ in Hz
Range	$f_N \pm 5$ Hz
Tolerance*)	20 mHz
Voltage difference ($V2 - V1$)	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance*)	≤1 % of measured value or 0.5 % of V_{nom}
Frequency difference ($f2 - f1$)	In mHz
Range	$f_N \pm 5$ Hz
Tolerance*)	20 mHz
Angle difference ($\alpha2 - \alpha1$)	In °
Range	0 to 180 °
Tolerance*)	0.5 °

*) With rated frequency.

1) At $I_{\text{nom}} = 1$ A, all limits divided by 5.

Negative-sequence current detection *(ANSI 46)*	
Definite-time characteristic *(ANSI 46-1 and 46-2)*	
Setting ranges	
Pickup current $I_2>$, $I_2>>$	0.5 to 15 A or ∞ (in steps of 0.01 A)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Dropout delay time T_{DO}	0 to 60 s (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A 1)
Times	
Pickup times	Approx. 35 ms
Dropout times	Approx. 35 ms
Dropout ratio	Approx. 0.95 for $I_2 / I_{\text{nom}} > 0.3$
Tolerances	
Pickup thresholds	3 % of the setting value or 50 mA 1)
Delay times	1 % or 10 ms
Inverse-time characteristic *(ANSI 46-TOC)*	
Setting ranges	
Pickup current	0.5 to 10 A 1) (in steps of 0.01 A)
Time multiplier T (IEC characteristics)	0.05 to 3.2 s or ∞ (in steps of 0.01 s)
Time multiplier D (ANSI characteristics)	0.5 to 15 s or ∞ (in steps of 0.01 s)
Functional limit	All phase currents ≤ 20 A 1)
Trip characteristics	
IEC	Normal inverse, very inverse, extremely inverse
ANSI	Inverse, moderately inverse, very inverse, extremely inverse
Pickup threshold	Approx. 1.1 · I_{2p} setting value
Dropout	
IEC and ANSI (without disk emulation)	Approx. 1.05 · I_{2p} setting value, which is approx. 0.95 · pickup threshold
ANSI with disk emulation	Approx. 0.90 · I_{2p} setting value
Tolerances	
Pickup threshold	3 % of the setting value or 50 mA 1)
Time for 2 ≤ M ≤ 20	5 % of setpoint (calculated) +2 % current tolerance, at least 30 ms
Flexible protection functions *(ANSI 27, 32, 47, 50, 55, 59, 81R)*	
Operating modes / measuring quantities	
3-phase	I, I_1, I_2, $3I_0$, V, V_1, V_2, $3V_0$, P, Q, cos φ
1-phase	I, I_E, $I_{E\,sens.}$, V, V_E, P, Q, cos φ
Without fixed phase relation	f, df/dt, binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current I, I_1, I_2, $3I_0$, I_E	0.25 to 175 A 1) (in steps of 0.01 A)
Sens. earth curr. $I_{E\,sens.}$	0.001 to 1.5 A (in steps of 0.001 A)
Voltages V, V_1, V_2, $3V_0$	1 to 260 V (in steps of 0.1 V)
Displacement voltage V_E	1 to 200 V (in steps of 0.1 V)
Power P, Q	0.5 to 10000 W (in steps of 0.1 W)
Power factor (cos φ)	- 0.99 to + 0.99 (in steps of 0.01)
Frequency $f_N = 50$ Hz	45.5 to 54.5 Hz (in steps of 0.1 Hz)
$f_N = 60$ Hz	55.5 to 64.5 Hz (in steps of 0.1 Hz)
Rate-of-frequency change df/dt	0.1 to 20 Hz/s (in steps of 0.01 Hz/s)
Pickup delay time	0 to 60 s (in steps of 0.01 s)
Trip delay time	0 to 3600 s (in steps of 0.01 s)
Dropout delay time	0 to 60 s (in steps of 0.01 s)

Technical data

Times	
Pickup times	
Current, voltage (phase quantities)	
With 2 times the setting value	Approx. 30 ms
With 10 times the setting value	Approx. 20 ms
Current, voltages (symmetrical components)	
With 2 times the setting value	Approx. 40 ms
With 10 times the setting value	Approx. 30 ms
Power	
Typical	Approx. 120 ms
Maximum (low signals and thresholds)	Approx. 350 ms
Power factor	300 to 600 ms
Frequency	Approx. 100 ms
Rate-of-frequency change	
Typical	Approx. 220 ms
Maximum	1 s
Binary input	Approx. 20 ms
Dropout times	
Current, voltage (phase quantities)	< 20 ms
Current, voltages (symmetrical components)	< 30 ms
Power	
Typical	< 50 ms
Maximum	< 350 ms
Power factor	< 300 ms
Frequency	< 100 ms
Rate-of-frequency change	< 200 ms
Binary input	< 10 ms
Dropout ratio >- stage	1.01 to 3 (in steps of 0.01)
Dropout ratio <- stage	0.7 to 0.99 (in steps of 0.01)
Tolerances	
Pickup threshold	
Current	1 % of setting value or 50 mA[1)]
Current (symmetrical components)	2 % of setting value or 100 mA[1)]
Voltage	1 % of setting value or 0.1 V
Voltage (symmetrical components)	2 % of setting value or 0.2 V
Power	1 % of setting value or 0.3 W
Power factor	2 degrees
Frequency	10 mHz
Rate-of-frequency change	5 % of setting value or 0.05 Hz/s
Times	1 % of setting value or 10 ms

Starting time monitoring for motors *(ANSI 48)*

Setting ranges	
Motor starting current $I_{STARTUP}$	2.5 to 80 A[1)] (in steps of 0.01)
Pickup threshold $I_{MOTOR\ START}$	2 to 50 A[1)] (in steps of 0.01)
Permissible starting time $T_{STARTUP}$	1 to 180 s (in steps of 0.1 s)
Permissible blocked rotor time $T_{LOCKED\text{-}ROTOR}$	0.5 to 120 s or ∞ (in steps of 0.1 s)
Tripping time characteristic for $I > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I}\right)^2 \cdot T_{STARTUP}$ $I_{STARTUP}$ = Rated motor starting current I = Actual current flowing $T_{STARTUP}$ = Tripping time for rated motor starting current t = Tripping time in seconds
Dropout ratio $I_{MOTOR\ START}$	Approx. 0.95
Tolerances	
Pickup threshold	2 % of setting value or 50 mA[1)]
Delay time	5 % or 30 ms

Restart inhibit for motors *(ANSI 66)*

Setting ranges	
Motor starting current relative to rated motor current $I_{MOTOR\ START}/I_{Motor\ Nom}$	1.1 to 10 (in steps of 0.1)
Rated motor current $I_{Motor\ Nom}$	1 to 6 A[1)] (in steps of 0.01 A)
Max. permissible starting time $T_{Start\ Max}$	3 to 320 s (in steps of 1 s)
Equilibrium time T_{Equal}	0 to 320 min (in steps of 0.1 min)
Minimum inhibit time $T_{MIN.\ INHIBIT\ TIME}$	0.2 to 120 min (in steps of 0.1 min)
Max. permissible number of warm starts	1 to 4 (in steps of 1)
Difference between cold and warm starts	1 to 2 (in steps of 1)
Extension k-factor for cooling simulations of rotor at zero speed $k_{\tau\ at\ STOP}$	0.2 to 100 (in steps of 0.1)
Extension factor for cooling time constant with motor running $k_{\tau\ RUNNING}$	0.2 to 100 (in steps of 0.1)
Restarting limit	$\Theta_{restart} = \Theta_{rot\ max\ perm} \cdot \frac{n_c - 1}{n_c}$ $\Theta_{restart}$ = Temperature limit below which restarting is possible $\Theta_{rot\ max\ perm}$ = Maximum permissible rotor overtemperature (= 100 % in operational measured value $\Theta_{rot}/\Theta_{rot\ trip}$) n_c = Number of permissible start-ups from cold state

Undercurrent monitoring *(ANSI 37)*

Signal from the operational measured values	Predefined with programmable logic

Temperature monitoring box *(ANSI 38)*

Temperature detectors	
Connectable boxes	1 or 2
Number of temperature detectors per box	Max. 6
Type of measuring	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting identification	"Oil" or "Environment" or "Stator" or "Bearing" or "Other"
Thresholds for indications	
For each measuring detector	
Stage 1	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)
Stage 2	-50 °C to 250 °C (in steps of 1 °C) -58 °F to 482 °F (in steps of 1 °F) or ∞ (no indication)

1) At I_{nom} = 1 A, all limits divided by 5.

Technical data

Undervoltage protection *(ANSI 27)*	
Operating modes/measuring quantities	
3-phase	Positive-sequence component or smallest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V<$, $V<<$	
3-phase, phase-earth connection	10 to 210 V (in steps of 1 V)
3-phase, phase-phase connection	10 to 120 V (in steps of 1 V)
1-phase connection	10 to 120 V (in steps of 1 V)
Dropout ratio r	1.01 to 3 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Current Criteria "Bkr Closed I_{MIN}"	0.2 to 5 A[1] (in steps of 0.01 A)
Dropout threshold $r \cdot V<(<)$	Max. 130 V for phase-phase voltages Max. 225 V phase-earth voltages
Times	
Pickup times $V<$, $V<<$, $V_1<$, $V_1<<$	Approx. 50 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms

Overvoltage protection *(ANSI 59)*	
Operating modes/measuring quantities	
3-phase	Negative-sequence component or largest of the phase-to-phase voltages
1-phase	Single-phase phase-earth or phase-phase voltage
Setting ranges	
Pickup thresholds $V>$, $V>>$	
3-phase, phase-earth connection, largest phase-phase voltage	40 to 260 V (in steps of 1 V)
3-phase, phase-phase connection, largest phase-phase voltage	40 to 150 V (in steps of 1 V)
3-phase, negative-sequence voltage	2 to 150 V (in steps of 1 V)
1-phase connection	40 to 150 V (in steps of 1 V)
Dropout ratio r	0.9 to 0.99 (in steps of 0.01)
Delay times T	0 to 100 s or ∞ (in steps of 0.01 s)
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Pickup times $V_2>$, $V_2>>$	Approx. 60 ms
Dropout times	As pickup times
Tolerances	
Pickup thresholds	3 % of setting value or 1 V
Times	1 % of setting value or 10 ms

1) At I_{nom} = 1 A, all limits divided by 5.

2) At I_{nom} = 1 A, all limits multiplied with 5.

3) At rated frequency.

Frequency protection *(ANSI 81)*	
Number of frequency elements	4
Setting ranges	
Pickup thresholds for f_{nom} = 50 Hz	45.5 to 54.5 Hz (in steps of 0.01 Hz)
Pickup thresholds for f_{nom} = 60 Hz	55.5 to 64.5 Hz (in steps of 0.01 Hz)
Delay times	0 to 100 s or ∞ (in steps of 0.01 s)
Undervoltage blocking, with positive-sequence voltage V_1	10 to 150 V (in steps of 1 V)
Times	
Pickup times	Approx. 80 ms
Dropout times	Approx. 75 ms
Dropout	
Δf = pickup value - dropout value	Approx. 20 mHz
Ratio undervoltage blocking	Approx. 1.05
Tolerances	
Pickup thresholds	
Frequency	10 mHz
Undervoltage blocking	3 % of setting value or 1 V
Delay times	3 % of the setting value or 10 ms

Fault locator *(ANSI 21FL)*	
Output of the fault distance	In Ω secondary, in km / mile of line length
Starting signal	Trip command, dropout of a protection element, via binary input
Setting ranges	
Reactance (secondary)	0.001 to 1.9 Ω/km[2] (in steps of 0.0001) 0.001 to 3 Ω/mile[2] (in steps of 0.0001)
Tolerances	
Measurement tolerance acc. to VDE 0435, Part 303 for sinusoidal measurement quantities	2.5 % fault location, or 0.025 Ω (without intermediate infeed) for $30° \leq \varphi K \leq 90°$ and $V_K/V_{nom} \geq 0.1$ and $I_K/I_{nom} \geq 1$

Additional functions	
Operational measured values	
Currents I_{L1}, I_{L2}, I_{L3} Positive-sequence component I_1 Negative-sequence component I_2 I_E or $3I_0$	In A (kA) primary, in A secondary or in % I_{nom}
Range	10 to 200 % I_{nom}
Tolerance[3]	1 % of measured value or 0.5 % I_{nom}
Phase-to-earth voltages V_{L1-E}, V_{L2-E}, V_{L3-E} Phase-to-phase voltages V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, V_{SYN}, V_E or V_0 Positive-sequence component V_1 Negative-sequence component V_2	In kV primary, in V secondary or in % V_{nom}
Range	10 to 120 % V_{nom}
Tolerance[3]	1 % of measured value or 0.5 % of V_{nom}
S, apparent power	In kVAr (MVAr or GVAr) primary and in % of S_{nom}
Range	0 to 120 % S_{nom}
Tolerance[3]	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 %
P, active Power	With sign, total and phase-segregated in kW (MW or GW) primary and in % S_{nom}
Range	0 to 120 % S_{nom}
Tolerance[3]	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert\cos\varphi\rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$

5

Technical data

Q, reactive power	With sign, total and phase-segregated in kVAr (MVAr or GVAr)primary and in % S_{nom}
Range	0 to 120 % S_{nom}
Tolerance[1)]	1 % of S_{nom} for V/V_{nom} and I/I_{nom} = 50 to 120 % and $\lvert \sin \varphi \rvert$ = 0.707 to 1 with $S_{nom} = \sqrt{3} \cdot V_{nom} \cdot I_{nom}$
cos φ, power factor (p.f.)	Total and phase segregated
Range	- 1 to + 1
Tolerance[1)]	2 % for $\lvert \cos \varphi \rvert \geq 0.707$
Frequency f	In Hz
Range	$f_{nom} \pm 5$ Hz
Tolerance[1)]	20 mHz
Temperature overload protection Θ/Θ_{Trip}	In %
Range	0 to 400 %
Tolerance[1)]	5 % class accuracy per IEC 60255-8
Temperature restart inhibit $\Theta_L/\Theta_{L\ Trip}$	In %
Range	0 to 400 %
Tolerance[1)]	5 % class accuracy per IEC 60255-8
Restart threshold $\Theta_{Restart}/\Theta_{L\ Trip}$	In %
Reclose time $T_{Reclose}$	In min
Currents of sensitive ground fault detection (total, real, and reactive current) I_{EE}, $I_{EE\ real}$, $I_{EE\ reactive}$	In A (kA) primary and in mA secondary
Range	0 mA to 1600 mA
Tolerance[1)]	2 % of measured value or 1 mA
RTD-box	See section "Temperature monitoring box"
Synchronism and voltage check	See section "Synchronism and voltage check"
Long-term averages	
Time window	5, 15, 30 or 60 minuets
Frequency of updates	Adjustable
Long-term averages	
of currents	I_{L1dmd}, I_{L2dmd}, I_{L3dmd}, I_{1dmd} in A (kA)
of real power	P_{dmd} in W (kW, MW)
of reactive power	Q_{dmd} in VAr (kVAr, MVAr)
of apparent power	S_{dmd} in VAr (kVAr, MVAr)
Max. / Min. report	
Report of measured values	With date and time
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./Max. values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component)
Min./Max. values for voltages	V_{L1-E}, V_{L2-E}, V_{L3-E} V_1 (positive-sequence component) V_{L1-L2}, V_{L2-L3}, V_{L3-L1}
Min./Max. values for power	S, P, Q, cos φ, frequency

1) At rated frequency.

Min./Max. values for overload protection	Θ/Θ_{Trip}
Min./Max. values for mean values	I_{L1dmd}, I_{L2dmd}, I_{L3dmd} I_1 (positive-sequence component); S_{dmd}, P_{dmd}, Q_{dmd}
Local measured values monitoring	
Current asymmetry	I_{max}/I_{min} > balance factor, for $I > I_{balance\ limit}$
Voltage asymmetry	V_{max}/V_{min} > balance factor, for $V > V_{lim}$
Current sum	$\lvert i_{L1} + i_{L2} + i_{L3} + k_{iE} \cdot i_E \rvert$ > limit value, with $k_{iE} = \frac{I_{earth}\ \text{CT PRIM} / I_{earth}\ \text{CT SEC}}{\text{CT PRIM} \ /\text{CT SEC}}$
Current phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Voltage phase sequence	Clockwise (ABC) / counter-clockwise (ACB)
Limit value monitoring	Predefined limit values, user-defined expansions via CFC
Fault recording	
Recording of indications of the last 8 power system faults	
Recording of indications of the last 3 power system ground faults	
Time stamping	
Resolution for event log (operational annunciations)	1 ms
Resolution for trip log (fault annunciations)	1 ms
Maximum time deviation (internal clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA, message "Battery Fault" for insufficient battery charge
Oscillographic fault recording	
Maximum 8 fault records saved, memory maintained by buffer battery in case of loss of power supply	
Recording time	Total 20 s Pre-trigger and post-fault recording and memory time adjustable
Sampling rate for 50 Hz Sampling rate for 60 Hz	1 sample/1.25 ms (16 sam/cyc) 1 sample/1.04 ms (16 sam/cyc)
Energy/power	
Meter values for power Wp, Wq (real and reactive power demand)	in kWh (MWh or GWh) and kVARh (MVARh or GVARh)
Tolerance[1)]	≤ 5 % for $I > 0.5\ I_{nom}$, $V > 0.5\ V_{nom}$ and $\lvert \cos \varphi \rvert$ (p.f.) ≥ 0.707
Statistics	
Saved number of trips	Up to 9 digits
Number of automatic reclosing commands (segregated according to 1st and ≥ 2nd cycle)	Up to 9 digits

Technical data

Circuit-breaker wear	
Methods	• ΣI^x with x = 1 .. 3 • 2-point method (remaining service life) • $\Sigma i^2 t$
Operation	Phase-selective accumulation of measured values on TRIP command, up to 8 digits, phase-selective limit values, monitoring indication
Operating hours counter	
Display range	Up to 7 digits
Criterion	Overshoot of an adjustable current threshold (BkrClosed I_{MIN})
Trip circuit monitoring	
With one or two binary inputs	
Commissioning aids	
Phase rotation field check, operational measured values, circuit-breaker / switching device test, creation of a test measurement report	
Clock	
Time synchronization	DCF77/IRIG-B signal (telegram format IRIG-B000), binary input, communication
Setting group switchover of the function parameters	
Number of available setting groups	4 (parameter group A, B, C and D)
Switchover performed	Via keypad, DIGSI, system (SCADA) interface or binary input
Control	
Number of switching units	Depends on the binary inputs and outputs
Interlocking	Programmable
Circuit-breaker signals	Feedback, close, open, intermediate position
Control commands	Single command / double command 1, 1 plus 1 common or 2 trip contacts
Programmable controller	CFC logic, graphic input tool
Local control	
Units with small display	Control via menu, assignment of a function key
Units with large display	Control via menu, control with control keys
Remote control	Via communication interfaces, using a substation automation and control system (e.g. SICAM), DIGSI 4 (e.g. via modem)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

5

Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	7SJ64□□ – □□□□□ – □□□□
Housing, binary inputs and outputs	
Housing 1/3 19”, 7 BI, 5 BO, 1 live-status contact, text display 4 x 20 character (only for 7SJ640) 9th position only with: B, D, E	0
Housing 1/2 19”, 15 BI, 13 BO (1 NO/NC or 1a/b contact), 1 live-status contact, graphic display	1
Housing 1/2 19”, 20 BI, 8 BO, 4 (2) power relays, 1 live-status contact, graphic display	2
Housing 1/1 19”, 33 BI, 11 BO, 8 (4) power relays, 1 live-status contact, graphic display	5
Measuring inputs (4 x V, 4 x I)	
I_{ph} = 1 A[1], I_e = 1 A[1] (min. = 0.05 A) Position 15 only with A, C, E, G	1
I_{ph} = 1 A[1], I_e = sensitive (min. = 0.001 A) Position 15 only with B, D, F, H	2
I_{ph} = 5 A[1], I_e = 5 A[1] (min. = 0.25 A) Position 15 only with A, C, E, G	5
I_{ph} = 5 A[1], I_e = sensitive (min. = 0.001 A) Position 15 only with B, D, F, H	6
I_{ph} = 5 A[1], I_e = 1 A[1] (min. = 0.05 A) Position 15 only with A, C, E, G	7
Rated auxiliary voltage (power supply, binary inputs)	
24 to 48 V DC, threshold binary input 19 V DC[3]	2
60 to 125 V DC[2], threshold binary input 19 V DC[3]	4
110 to 250 V DC[2], 115 to 230 V AC[4], threshold binary input 88 V DC[3]	5
Unit version	
Surface-mounting housing, plug-in terminals, detached operator panel, panel mounting in low-voltage housing	A
Surface-mounting housing, 2-tier terminals on top/bottom	B
Surface-mounting housing, screw-type terminals (direct connection/ ring-type cable lugs), detached operator panel, panel mounting in low-voltage housing	C
Flush-mounting housing, plug-in terminals (2/3 pin connector)	D
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	E
Surface-mounting housing, screw-type terminals (direct connection/ring-type cable lugs), without operator panel, panel mounting in low-voltage housing	F
Surface-mounting housing, plug-in terminals, without operator panel, panel mounting in low-voltage housing	G
Region-specific default settings/function versions and language settings	
Region DE, 50 Hz, IEC, language: German (language selectable)	A
Region World, 50/60 Hz, IEC/ANSI, language: English (GB) (language selectable)	B
Region US, 60 Hz, ANSI, language: English (US) (language selectable)	C
Region FR, 50/60 Hz, IEC/ANSI, language: French (language selectable)	D
Region World, 50/60 Hz, IEC/ANSI, language: Spanish (language selectable)	E

see next page

1) Rated current can be selected by means of jumpers
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
3) The binary input thresholds can be selected per binary input by means of jumpers.
4) 230 V AC, starting from unit version.../CC

Selection and ordering data

Description	Order No.	Order code
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□*	*□□□*
	see following pages	
System interface (on rear of unit, Port B)		
No system interface	0	
IEC 60870-5-103 protocol, RS232	1	
IEC 60870-5-103 protocol, RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber, ST connector	3	
PROFIBUS-FMS Slave, RS485	4	
PROFIBUS-FMS Slave, 820 nm wavelength, single ring, ST connector 1)	5	
PROFIBUS-FMS Slave, 820 nm wavelength, double ring, ST connector 1)	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm wavelength, double ring, ST connector 1)	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm wavelength, ST connector 2)	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm wavelength, ST connector 2)	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector (EN 100) 2)	9	L 0 S
Only Port C (service interface)		
DIGSI 4/modem, electrical RS232	1	
DIGSI 4/modem/RTD-box 3), electrical RS485	2	
Port C and D (service and additional interface)	9	M □ □
Port C (service interface)		
DIGSI 4/modem, electrical RS232		1
DIGSI 4/modem/RTD-box 3), electrical RS485		2
Port D (additional interface)		
RTD-box 3), 820 nm fiber, ST connector 4)		A
RTD-box 3), electrical RS485		F
Measuring/fault recording		
Fault recording	1	
Slave pointer, mean values, min/max values, fault recording	3	

1) Not with position 9 = "*B*"; if 9 = "*B*", please order 7SJ6 unit with RS485 port and separate fiber-optic converters.
For single ring, please order converter 6GK1502-2CB10, not available with position 9 = "*B*".
For double ring, please order converter 6GK1502-3CB10, not available with position 9 = "*B*".
The converter requires a 24 V AC power supply (e.g. power supply 7XV5810-0BA00).

2) Not available with position 9 = "*B*".

3) Temperature monitoring box 7XV5662-□AD10, refer to "Accessories".

4) When using the RTD-box at an optical interface, the additional RS485 fiber-optic converter 7XV5650-0□A00 is required.

5

Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□*

Designation				ANSI No.	Description	Order No.
Basic version					Control	
				50/51	Time-overcurrent protection $I>$, $I>>$, I_p, reverse interlocking	
				50N/51N	Earth-fault protection $I_E>$, $I_E>>$, I_{Ep}	
				50N/51N	Insensitive earth-fault protection through IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} 1)	
				50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I>>>$, $I>>>>$, $I_E>>>$, $I_E>>>>$	
				49	Overload protection (with 2 time constants)	
				46	Phase balance current protection (negative-sequence protection)	
				37	Undercurrent monitoring	
				47	Phase sequence	
				59N/64	Displacement voltage	
				50BF	Breaker failure protection	
				74TC	Trip circuit supervision	
					4 setting groups, cold-load pickup	
					Inrush blocking	
				86	Lockout	*F A*
■			V, P, f	27/59 81 O/U 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F E*
■		IEF	V, P, f	27/59 81 O/U 27/47/59(N) 32/55/81R	Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection Intermittent earth fault	*P E*
■	Dir			67/67N	Direction determination for overcurrent, phases and earth	*F C*
■	Dir		V, P, f	67/67N 27/59 81O/U 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and earth Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*F G*
■	Dir	IEF		67/67N	Direction determination for overcurrent, phases and earth Intermittent earth fault	*P C*
Directional earth-fault detection ■	Dir			67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault	*F D* 2)
Directional earth-fault detection ■	Dir	IEF		67/67N 67Ns 87N	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Intermittent earth fault	*P D* 2)

■ Basic version included

V, P, f = Voltage, power, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Continued on next page

Selection and ordering data

Description	Order No.
7SJ64 multifunction protection relay with synchronization	*7SJ64☐☐ – ☐☐☐☐☐ – ☐☐☐☐*

Designation	ANSI No.	Description	
Basic version		Control	
	50/51	Time-overcurrent protection $I>$, $I>>$, I_p, reverse interlocking	
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, I_{Ep}	
	50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} [1)]	
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I>>>$, $I>>>>$, $I_E>>>$, $I_E>>>>$	
	49	Overload protection (with 2 time constants)	
	46	Phase balance current protection (negative-sequence protection)	
	37	Undercurrent monitoring	
	47	Phase sequence	
	59N/64	Displacement voltage	
	50BF	Breaker failure protection	
	74TC	Trip circuit supervision	
		4 setting groups, cold-load pickup	
		Inrush blocking	
	86	Lockout	
Directional earth-fault detection ■	67Ns 87N	Directional sensitive earth-fault detection, High-impedance restricted earth fault	*F B* [2)]
Directional earth-fault detection ■ Motor V, P, f	67Ns 87N 48/14 66/86 27/59 81O/U 27/47/59(N) 32/55/81R	Directional sensitive earth-fault detection, High-impedance restricted earth fault Starting time supervision, locked rotor Restart inhibit Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H F* [2)]
Directional earth-fault detection Motor Dir V, P, f	67/67N 67Ns 87N 48/14 66/86 27/59 81O/U 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Starting time supervision, locked rotor Restart inhibit Under-/overvoltage Under-/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H H* [2)]
Directional earth-fault detection ■ Motor Dir IEF V, P, f	67/67N 67Ns 87N 48/14 66/86 27/59 81O/U 27/47/59(N) 32/55/81R	Direction determination for overcurrent, phases and earth Directional sensitive earth-fault detection High-impedance restricted earth fault Intermittent earth fault Starting time supervision, locked rotor Restart inhibit Undervoltage/overvoltage Underfrequency/overfrequency Flexible protection (index quantities derived from current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*R H* [2)]

■ Basic version included

V, P, f = Voltage, power, frequency protection
Dir = Directional overcurrent protection
IEF = Intermittent earth fault

1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

2) For isolated/compensated networks only with sensitive earth-current transformer when position 7 = *2, 6*.

Continued on next page

Selection and ordering data

Description	Order No.	Order-code
7SJ64 multifunction protection relay with synchronization	*7SJ64□□ – □□□□□ – □□□□ – □□□□*	

Designation	ANSI No.	Description	
Basic version		Control	
	50/51	Time-overcurrent protection $I>$, $I>>$, I_p, reverse interlocking	
	50N/51N	Earth-fault protection $I_E>$, $I_E>>$, I_{Ep}	
	50N/51N	Insensitive earth-fault protection via IEE function: $I_{EE}>$, $I_{EE}>>$, I_{EEp} [1)]	
	50/50N	Flexible protection functions (index quantities derived from current): Additional time-overcurrent protection stages $I>>>$, $I>>>>$, $I_E>>>$, $I_E>>>>$	
	49	Overload protection (with 2 time constants)	
	46	Phase balance current protection (negative-sequence protection)	
	37	Undercurrent monitoring	
	47	Phase sequence	
	59N/64	Displacement voltage	
	50BF	Breaker failure protection	
	74TC	Trip circuit supervision	
		4 setting groups, cold-load pickup	
		Inrush blocking	
	86	Lockout	
■ Motor Dir V, P, f	67/67N	Direction determination for overcurrent, phases and earth	
	48/14	Starting time supervision, locked rotor	
	66/86	Restart inhibit	
	27/59	Under-/overvoltage	
	81O/U	Under-/overfrequency	
	27/47/59(N)	Flexible protection (index quantities derived from	
	32/55/81R	current and voltages): Voltage, power, p.f., rate-of-frequency-change protection	*H G*
ARC, fault locator, synchronization			
	Without		*0*
	79	With auto-reclosure	*1*
	21FL	With fault locator	*2*
	79, 21FL	With auto-reclosure, with fault locator	*3*
	25	With synchronization	*4*
	25, 79, 21FL	With synchronization, auto-reclosure, fault locator	*7*
ATEX100 Certification For protection of explosion-protected motos (increased-safety type of protection "e"			*Z X 9 9*

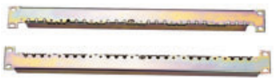
1) Only with insensitive earth-current transformer when position 7 = *1, 5, 7*.

Accessories

Description		Order No.
DIGSI 4		
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition		
Basis	Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional	DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
Professional + IEC 61850	Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
IEC 61850 System configurator		
Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		7XS5460-0AA00
SIGRA 4		
Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000 or XP Professional Edition. (generally contained in DIGSI Professional, but can be ordered additionally) Authorization by serial number. On CD-ROM.		7XS5410-0AA00
Temperature monitoring box		
24 to 60 V AC/DC		7XV5662-2AD10
90 to 240 V AC/DC		7XV5662-5AD10
Varistor/Voltage Arrester		
Voltage arrester for high-impedance REF protection		
125 Vrms; 600 A; 1S/S 256		C53207-A401-D76-1
240 Vrms; 600 A; 1S/S 1088		C53207-A401-D77-1
Connecting cable		
Cable between PC/notebook (9-pin con.) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		7XV5100-4
Cable between temperature monitoring box and SIPROTEC 4 unit		
- length 5 m /16.4 ft		7XV5103-7AA05
- length 25 m /82 ft		7XV5103-7AA25
- length 50 m /164 ft		7XV5103-7AA50
Manual for 7SJ62/63/64		
English		C53000-G1140-C147-6
French		C53000-G1177-C147-2
Spanish		C53000-G1178-C147-2
Catalog SIP 3.1 Spanish		E50001-K4403-A111-A1-7800

5

Accessories



Mounting rail

2-pin connector

3-pin connector

Short-circuit links for current terminals

Short-circuit links for other terminals

Description	Order No.	Size of package	Supplier
Terminal safety cover			
Voltage/current terminal 18-pole/12-pole	C73334-A1-C31-1	1	Siemens
Voltage/current terminal 12-pole/8-pole	C73334-A1-C32-1	1	Siemens
Connector 2-pin		1	Siemens
Connector 3-pin	C73334-A1-C36-1	1	Siemens
Crimp connector CI2 0.5 to 1 mm^2	0-827039-1	4000 taped on reel	AMP 1)
Crimp connector CI2 0.5 to 1 mm^2	0-827396-1	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163084-2	1	AMP 1)
Crimp connector: Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000 taped on reel	AMP 1)
Crimping tool for Type III+	0-539635-1	1	AMP 1)
and matching female	0-539668-2	1	AMP 1)
Crimping tool for CI2	0-734372-1	1	AMP 1)
and matching female	1-734387-1	1	AMP 1)
Short-circuit links			
for current terminals	C73334-A1-C33-1	1	Siemens
for other terminals	C73334-A1-C34-1	1	Siemens
Mounting rail for 19" rack	C73165-A63-D200-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

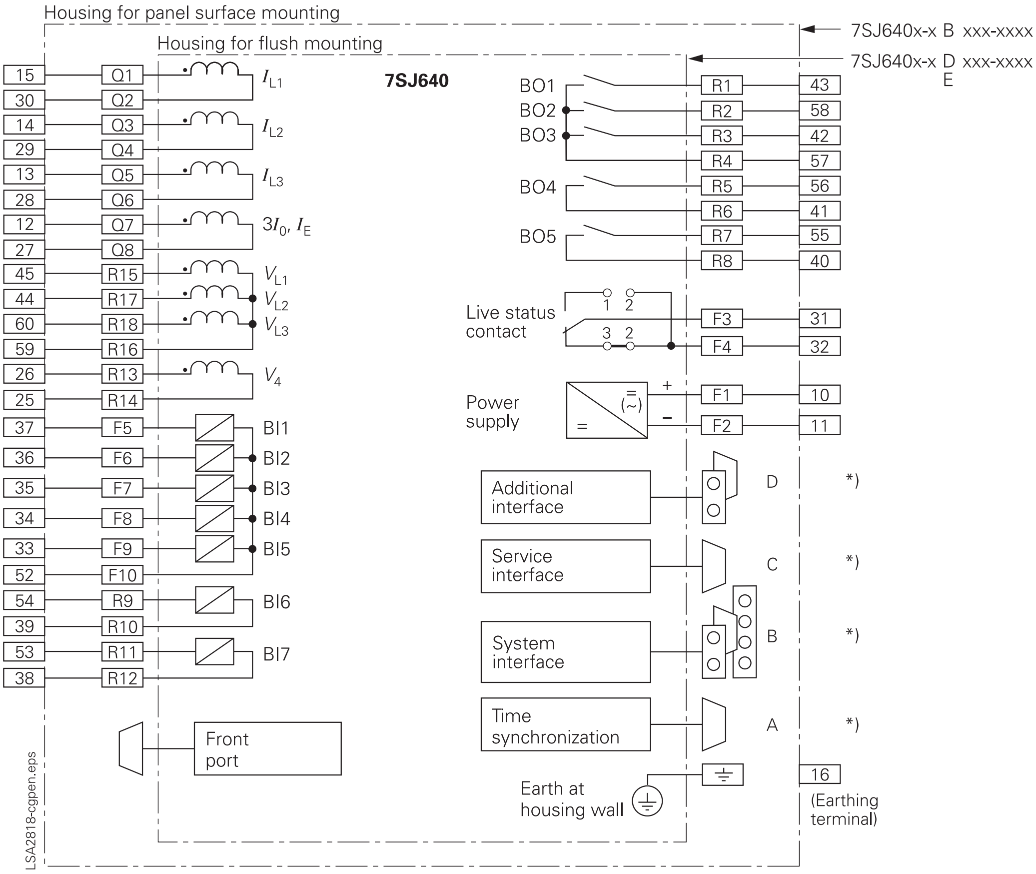


Fig. 5/177
7SJ640 connection diagram

*) For pinout of communication ports
see part 16 of this catalog.
For allocation of terminals of the panel surface mounting version
refer to the manual (http://www.siprotec.com).

Connection diagram

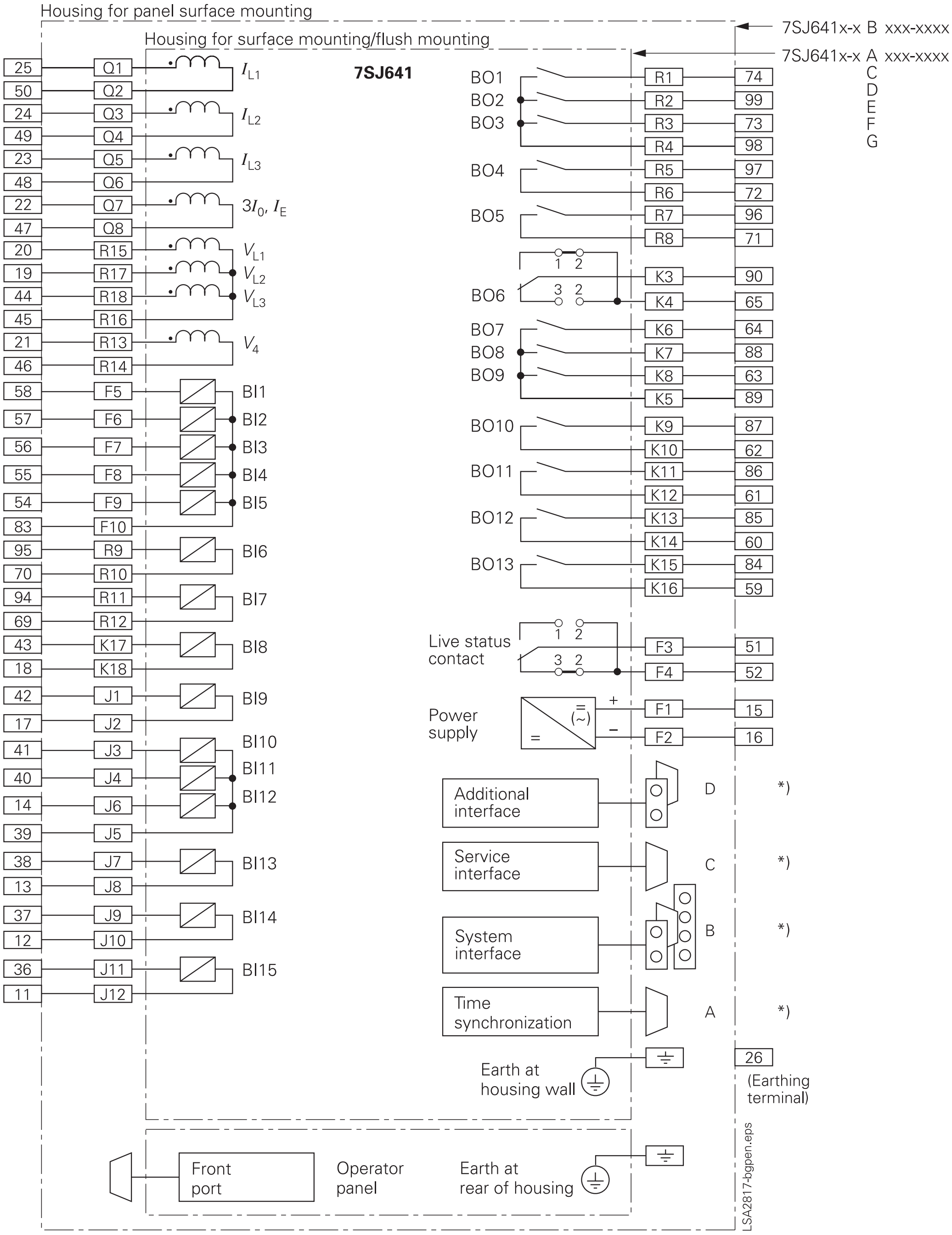


Fig. 5/178
7SJ641 connection diagram

*) For pinout of communication ports see part 16 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siprotec.com).

Connection diagram

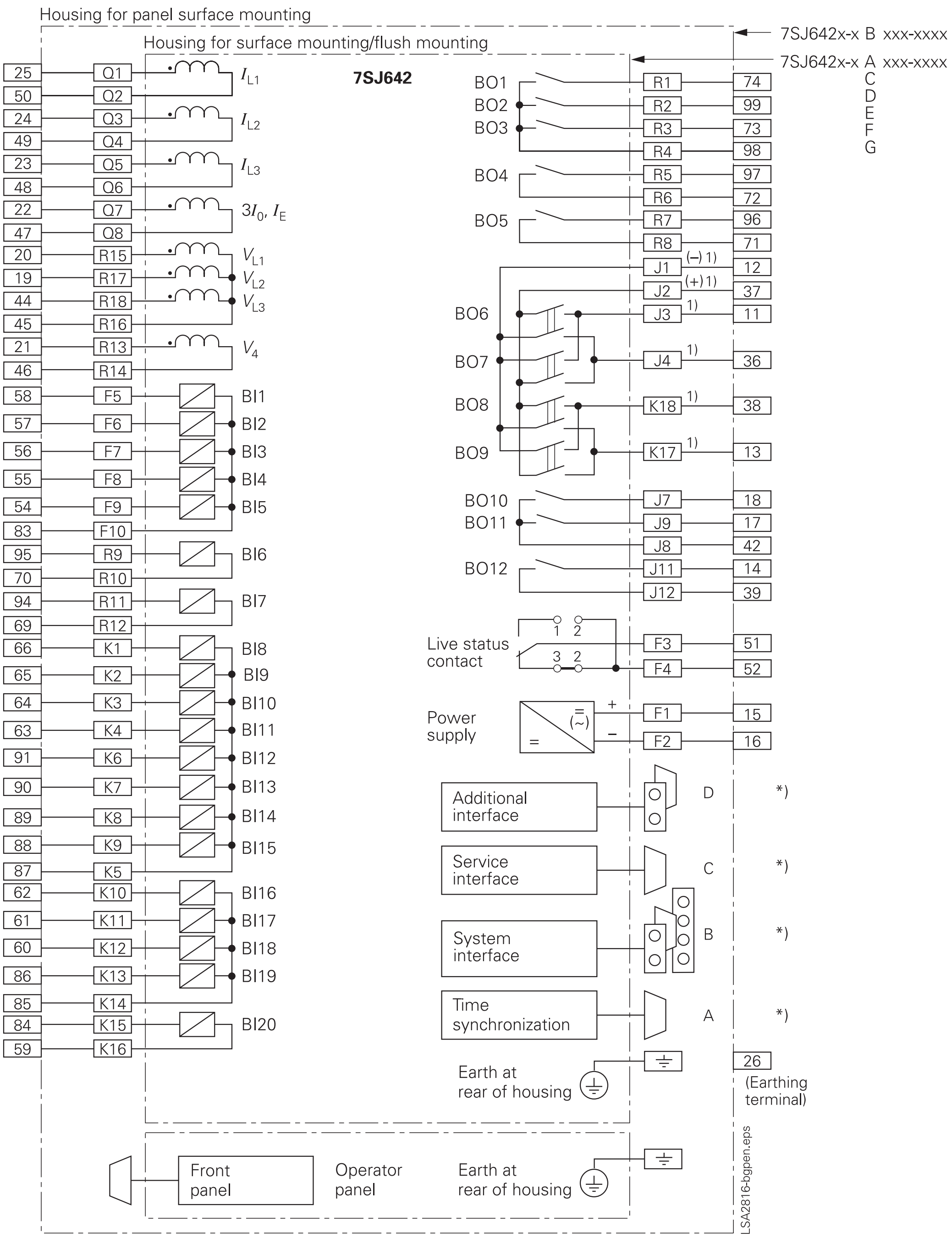
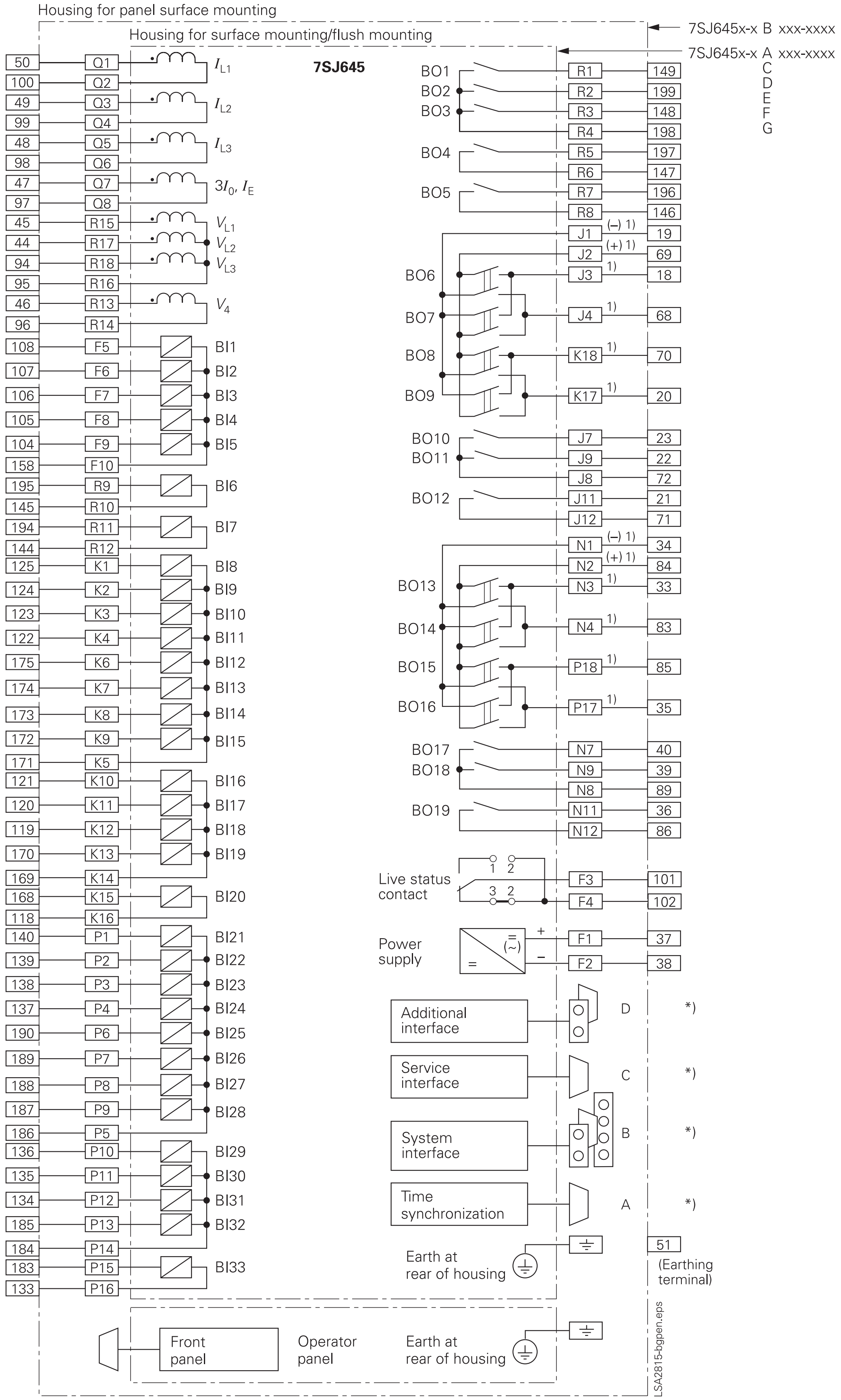


Fig. 5/179
7SJ642 connection diagram

*) For pinout of communication ports see part 16 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siprotec.com).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply. The power relay pairs are BO6/BO7, BO8/BO9. If used for protection purposes only one binary output of a pair can be used.

Connection diagram



*) For pinout of communication ports see part 16 of this catalog.
For allocation of terminals of the panel surface mounting version refer to the manual (http://www.siprotec.com).

1) Power relays are intended to directly control motorized switches. The power relays are interlocked so only one relay of each pair can close at a time, in order to avoid shorting out the power supply.
The power relay pairs are BO6/BO7, BO8/BO9, BO13/BO14, BO15/BO16.
If used for protection purposes only one binary output of a pair can be used.

Fig. 5/180
7SJ645 connection diagram

Distance Protection

Page

SIPROTEC 4 7SA6
Distance Protection Relay for all Voltage Levels

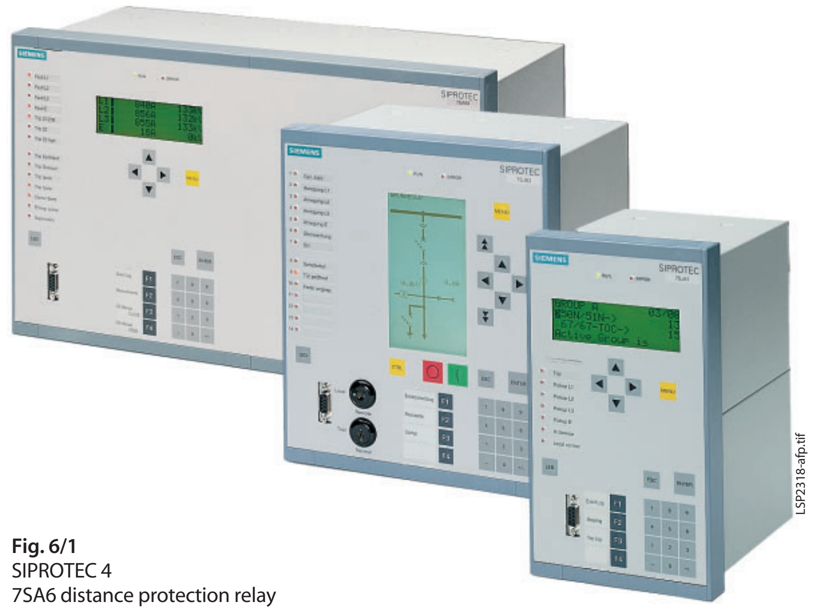


Fig. 6/1
SIPROTEC 4
7SA6 distance protection relay

Description

The SIPROTEC 4 7SA6 distance protection relay is a universal device for protection, control and automation on the basis of the SIPROTEC 4 system. Its high level of flexibility makes it suitable to be implemented at all voltage levels. With this relay you are ideally equipped for the future: it offers security of investment and also saves on operating costs.

– High-speed tripping time

– Low-impedance setpoints to protect also very short lines

– Self-setting power swing detection for frequencies up to 7 Hz

– Current transformer saturation detector ensures fast tripping and highest distance measurement accuracy

– Phase-segregated teleprotection for improved selectivity and availability

– Digital relay-to-relay communication by means of an integrated serial protection data interface

– Adaptive auto-reclosure (ADT)

Function overview

Protection functions

- Non-switched distance protection with 6 measuring systems (21/21N)
- High resistance earth-fault protection for single and three-phase tripping (50N, 51N, 67N)
- Earth-fault detection in isolated and resonant-earthed networks
- Tele (pilot) protection (85)
- Fault locator (FL)
- Power-swing detection/tripping (68/68T)
- Phase overcurrent protection (50/51/67)
- Switch-onto-fault protection (50HS)
- STUB bus overcurrent protection (50STUB)
- Overvoltage/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79)
- Synchro-check (25)
- Breaker failure protection (50BF)
- Thermal overload protection (49)

Control function

- Commands f. ctrl. of CBs and isolators

Monitoring functions

- Trip circuit supervision (74TC)
- Self-supervision of the relay
- Measured-value supervision
- Event logging/fault logging
- Oscillographic fault recording
- Switching statistics

Front design

- Easy operation w. numeric keys
- Function keys
- LEDs for local alarm
- PC front port for convenient relay setting

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
  – IEC 61850 Ethernet
  – IEC 60870-5-103 protocol
  – PROFIBUS-FMS/-DP
  – DNP 3.0
- 1 serial protection data interface for teleprotection
- Rear-side service/modem interface
- Time synchronization via
  – IRIG-B or DCF 77 or
  – system interface

6

Application

The distance protection relay 7SA6 is non-switched incorporating all the additional functions for protection of overhead lines and cables at all voltage levels from 5 to 765 kV.

All methods of neutral point connection (resonant earthing, isolated, solid or low-resistance earthing) are reliably dealt with. The unit can issue single or three-pole TRIP commands as well as CLOSE commands. Consequently both single-pole, three-pole and multiple auto-reclosure is possible.

Teleprotection functions as well as earth-fault protection and sensitive earth-fault detection are included. Power swings are detected reliably and non-selective tripping is prevented. The unit operates reliably and selectively even under the most difficult network conditions.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control or interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware. The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

ANSI	Protection functions
21/21N	Distance protection
FL	Fault locator
50N/51N 67N	Directional earth-fault protection
50/51/67	Backup overcurrent protection
50 STUB	STUB-bus overcurrent stage
68/68T	Power swing detection/tripping
85/21	Teleprotection for distance protection
27WI	Weak-infeed protection
85/67N	Teleprotection for earth-fault protection
50HS	Switch-onto-fault protection
50BF	Breaker-failure protection
59/27	Overvoltage/undervoltage protection
81O/U	Over/underfrequency protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)
49	Thermal overload protection
I_{EE}	Sensitive earth-fault detection

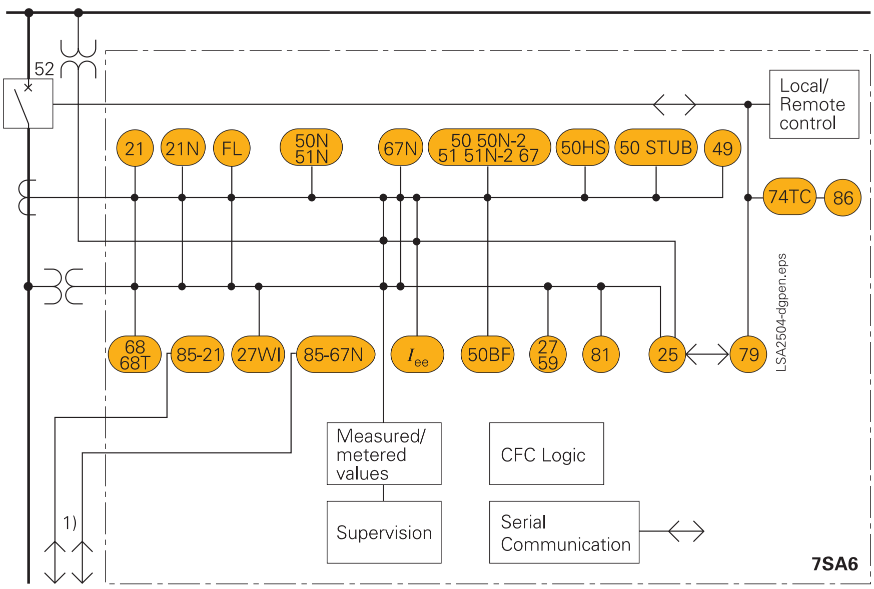


Fig. 6/2 Function diagram

1) Teleprotection schemes can use conventional signaling or serial data exchange

Construction

Connection techniques and housing with many advantages

1/3, 1/2, 2/3, and 1/1-rack sizes:
These are the available housing widths of the 7SA6 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option. It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing. The housing can also be supplied optionally with a detached operator panel (refer to Fig. 6/5), in order to allow optimum operation for all types of applications.


LSP2174-afp.tif

Fig. 6/3
Flush-mounting housing with screw-type terminals

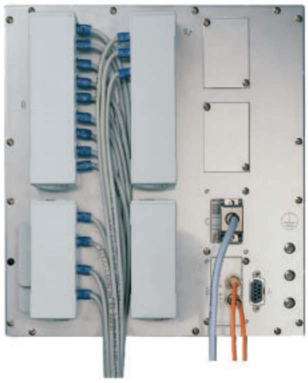

LSP2166-afp.tif

Fig. 6/4
Rear view of flush-mounting housing with covered connection terminals and wirings

LSP2244-afp.eps

Fig. 6/5 Flush-mounting housing with plug-in terminals and detached operator panel


LSP2219-afp.eps

Fig. 6/6
Surface-mounting housing with screw-type terminals


LSP2237-afp.tif

Fig. 6/7
Communication interfaces in a sloped case in a surface-mounting housing

6

Protection functions

Distance protection (ANSI 21, 21N)

The main function of the 7SA6 is a non-switched distance protection. By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of fault. The shortest tripping time is less than one cycle. All methods of neutral-point connection (resonant earthing, isolated, solid or low-resistance earthing) are reliably dealt with. Single-pole and three-pole tripping is possible. Overhead lines can be equipped with or without series capacitor compensation.

Four pickup methods

The following pickup methods can be employed alternatively:

- Overcurrent pickup $I{>>}$
- Voltage-dependent overcurrent pickup V/I
- Voltage-dependent and phase angle-dependent overcurrent pickup $V/I/\varphi$
- Impedance pickup $Z<$

Load zone

The pickup mode with quadrilateral impedance pickup ($Z<$) is fitted with a variable load zone. In order to guarantee a reliable discrimination between load operation and short-circuit (especially on long high loaded lines), the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity

The 7SA6 distance protection incorporates a well-proven, highly sophisticated phase selection algorithm. The pickup of unfaulted phases is reliably eliminated. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range. Interference to distance measurement caused by parallel lines can be compensated by taking the earth current of the parallel system into account.

This parallel line compensation can be taken into account both for distance measurement and for fault locating.

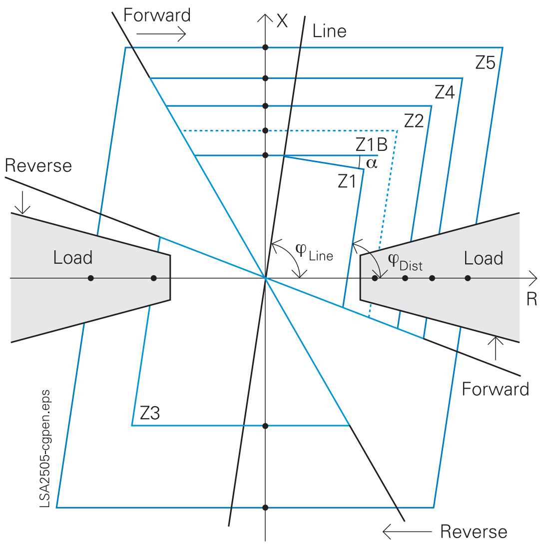


Fig. 6/8
Impedance fault detection $Z<$ with quadrilateral characteristic

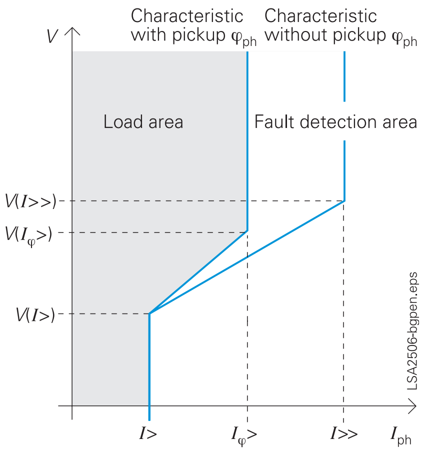


Fig. 6/9
Voltage and angle- dependent overcurrent fault detection $V/I/\varphi$

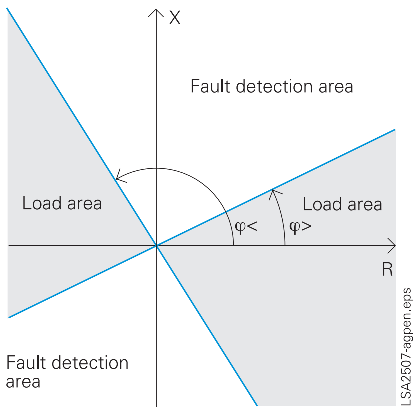


Fig. 6/10
Angle pickup for the $V/I/\varphi$ fault detection

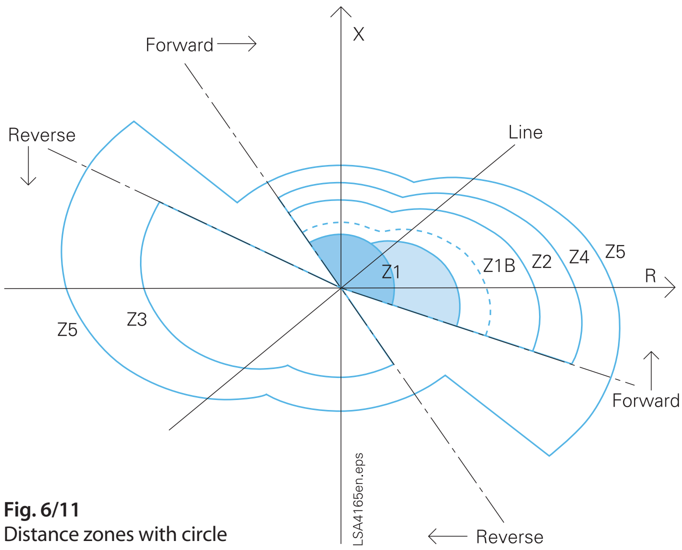


Fig. 6/11
Distance zones with circle characteristic

Protection functions

Six distance zones
Five independent distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partially separate for single-phase and three-phase faults. Earth faults are detected by monitoring the earth current $3I_0$ and the zero-sequence voltage $3V_0$. The quadrilateral tripping characteristic allows use of separate settings for the X and the R directions. Different R settings can be employed for earth and phase faults. This characteristic offers advantages in the case of faults with fault resistance. For applications to medium-voltage cables with low line angles, it may be advantageous to select the distance zones with the optional circle characteristic.
All the distance protection zones can be set to forward, reverse or non-directional.

Optimum direction detection
Use of voltages, which are not involved with the short-circuit loop, and of voltage memories for determination of the fault direction ensure that the results are always reliable.

Elimination of interference signals
Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring
Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.
The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and in this case the EMERGENCY definite-time overcurrent protection can be activated.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The results are displayed in ohms, kilometers (miles) and in percent of the line length. Parallel line compensation and load current compensation for high-resistance faults is also available.

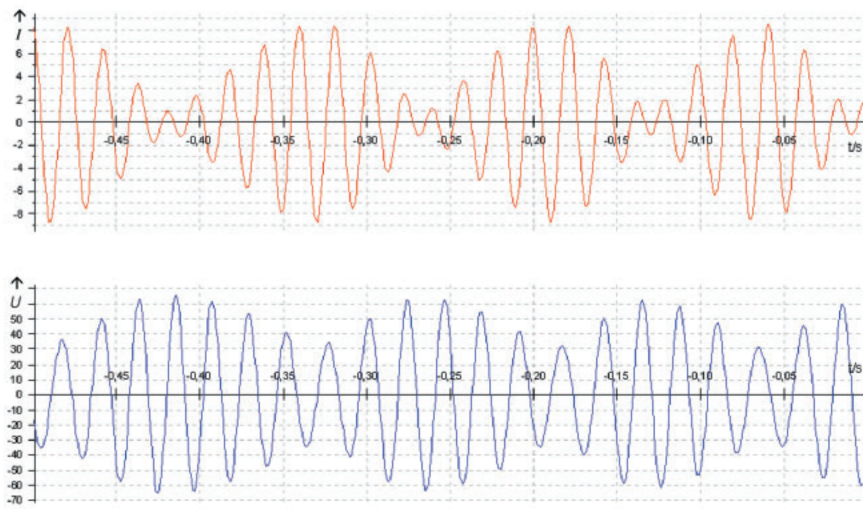


Fig. 6/12 Power swing current and voltage wave forms

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SA6 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- POTT
- Directional comparison pickup
- Unblocking
- PUTT acceleration with pickup
- PUTT acceleration with Z1B
- Blocking
- Pilot-wire comparison
- Reverse interlocking
- DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function).

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

Common transmission channels are power-line carrier microwave radio and fiber-optic links. A serial protection data interface for direct connection to a digital communication network or fiber-optic link is available.

7SA6 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines). Phase-selective transmission is also possible with multi-end application, if some user-specific linkages are implemented by way of the integrated CFC logic.

During disturbances in the signaling channel receiver or on the transmission circuit, the teleprotection function can be blocked via a binary input signal without losing the zone selectivity.

The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function.

Transient blocking (current reversal guard) is provided for all the release and blocking methods in order to suppress interference signals during tripping of parallel lines.

Protection functions

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SA6 relay is equipped with phase-selective intertripping signal inputs and outputs.

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided.
If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line.
It is also possible to initiate phase-selective tripping at the weak-infeed end. A phase-selective single-pole or three-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-earth voltage drops correspondingly. As an option, the weak infeed logic can be equipped according to a French specification.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or that are only lightly loaded. The 7SA6 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding)
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SA6 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Directional earth-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In an earthed network it may happen that the distance protection´s sensitivity is not sufficient to detect high-resistance earth faults. The 7SA6 protection relay therefore offers protection functions for faults of this nature.

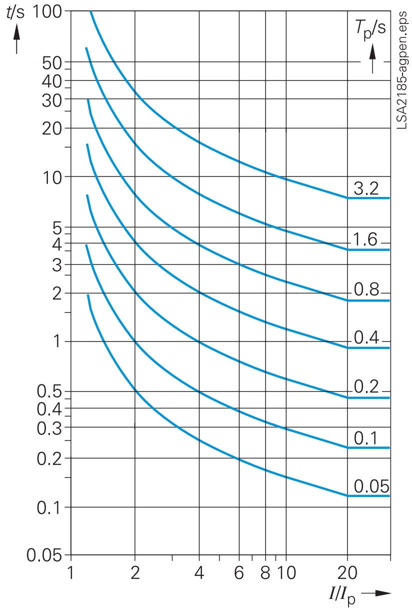
The earth-fault protection can be used with three definite-time stages and one inverse-time stage (IDMT).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data"). A 4th definite-time stage can be applied instead of the 1st inverse-time stage.

An additional logarithmic inverse-time characteristic is also available.

The direction decision is determined by the earth current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2. In addition or as an alternative, the direction can be determined with the earth current of an earthed power transformer and the zero-sequence voltage. Dual polarization applications can therefore be fulfilled. Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or in both directions (non-directional).

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for small zero-sequence fault currents which usually have a high content of 3rd and 5th harmonic.



$$t = \frac{0.14}{\left(I/I_p\right)^{0.02} - 1} T_p$$

Fig. 6/13 Normal inverse

Fig. 6/14
Transient earth-fault relay 7SN60

Protection functions

Inrush stabilization and instantaneous switch-onto-fault tripping can be activated separately for each stage as well.

Different operating modes can be selected. The earth-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

Tele (pilot) protection for directional earth-fault protection (ANSI 85-67N)

The directional earth-fault protection can be combined with the available signaling methods:

- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for earth-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N, 67)

The 7SA6 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the earth current. The application can be extended to a directional overcurrent protection (ANSI 67) by taking into account the decision of the available direction detection elements. Two operating modes are selectable. The function can run in parallel to the distance protection or only during failure of the voltage in the VT secondary circuit (emergency operation).

The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”).

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is required when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast three-pole tripping.

With smaller fault currents, instantaneous tripping after switch-onto-fault is also possible with the overreach distance zone Z1B or with pickup.

The switch-onto-fault initiation can be detected via the binary input “manual close” or automatically via measurement.

Earth-fault detection in systems with a star-point that is not effectively earthed

In systems with an isolated or resonant earthed (grounded) star-point, single-phase earth faults can be detected. The following functions are integrated for this purpose:

- Detection of an earth fault by monitoring of the displacement voltage
- Determination of the faulted phase by measurement of the phase-to-earth voltage
- Determination of the earth-fault direction by highly accurate measurement of the active and reactive power components in the residual earth fault current.
- Alarm or trip output can be selected in the event of an earth-fault in the forward direction.
- Operation measurement of the active and reactive component in the residual earth current during an earth-fault.

Earth-fault direction detection can also be effected on the basis of the transient earth-fault principle by interfacing with the additional unit 7SN60 (see Fig. 6/14). Procedures for logging, time stamping and event recording for the network control system are standardized by the 7SA6.

Breaker failure protection (ANSI 50BF)

The 7SA6 relay incorporates a two-stage breaker failure protection to detect failures of tripping command execution, for example, due to a defective circuit-breaker. The current detection logic is phase-selective and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command will be generated. The breaker failure protection can be initiated by all integrated protection functions, as well as by external devices via binary input signals.

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated via a binary input signaling that the open line isolator (disconnector) is open.

Separate settings are available for phase and earth faults.

Auto-reclosure (ANSI 79)

The 7SA6 relay is equipped with an auto-reclosure function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without earth, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosure for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without earth and 3-pole auto-reclosure for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the internal AR function by external protection
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Protection functions

Auto-reclosure (cont'd) (ANSI 79)

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no teleprotection method is employed: When faults within the zone extension but external to the protected line are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose a synchro-check function is provided. After verification of the network synchronism, the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g. checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Fuse failure monitoring and other supervision functions

The 7SA6 relay provides comprehensive supervision functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this supervision system.

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit, the distance protection would respond with an unwanted trip due to this loss of voltage.

This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection and switching to the backup-emergency overcurrent protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Broken-conductor supervision
- Summation of currents and voltages
- Phase-sequence supervision.

Directional power protection

The 7SA6 has a function for detecting the power direction by measuring the phase angle of the positive-sequence system's power. Fig. 6/15 shows an application example displaying negative active power. An indication is issued in the case when the measured angle φ (S1) of the positive-sequence system power is within the P - Q - level sector. This sector is between angles φ A and φ B. Via CFC the output signal of the directional monitoring can be linked to the "Direct Transfer Trip (DTT)" function and thus, as reverse power protection, initiate tripping of the CB.

Fig. 6/16 shows another application displaying capacitive reactive power. In the case of overvoltage being detected due to long lines under no-load conditions it is possible to select the lines where capacitive reactive power is measured.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

Under certain operating conditions it is advisable to block CLOSE commands after a TRIP command of the relay has been issued. Only a manual “RESET” command unblocks the CLOSE command. The 7SA6 is equipped with such an interlocking logic.

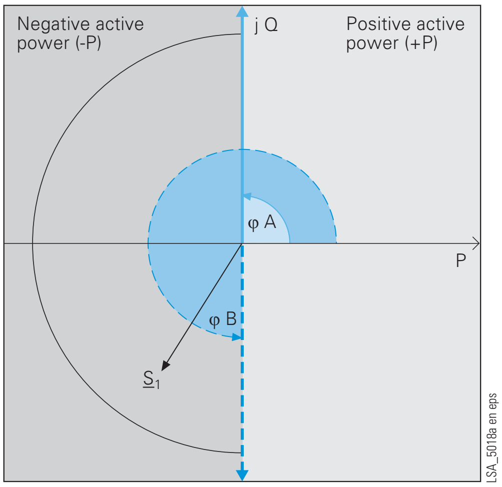


Fig. 6/15 Monitoring of active power direction

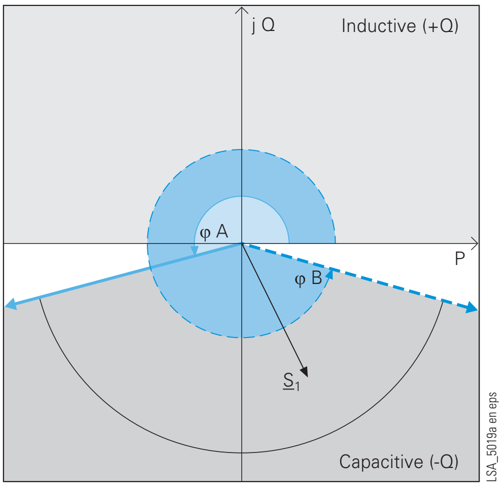


Fig. 6/16 Monitoring of reactive power

Thermal overload protection (ANSI 49)

For thermal protection of cables and transformers an overload protection with an early-warning stage is provided. The thermal replica can be generated with the maximum or mean value of the respective overtemperatures in the three phases, or with the overtemperature corresponding to the maximum phase current.

The tripping time characteristics are exponential functions according to IEC 60255-8 and they take account of heat loss due to the load current and the accompanying drop in temperature of the cooling medium. The previous load is therefore taken into account in the tripping time with overload. A settable alarm stage can output a current or temperature-dependent indication before the tripping point is reached.

Protection functions

BCD-coded output of fault location

The fault location calculated by the unit can be output for remote indication in BCD code. The output of the fault location is made in percent of the set line length with 3 decimal digits.

Analog output 0 to 20 mA

Some measured values can be output as analog values (0 to 20 mA). On a plug-in module (Fig. 6/21) two analog channels are made available. Up to two plug-in modules can be installed in the 7SA6. As an option, 2, 4 or no analog channels are available (please refer to the selection and ordering data). The available measured values can be gathered from the technical data.

Commissioning and fault event analyzing

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged. For applications with serial protection data interface, all currents, voltages and phases are available via communication link at each local unit, displayed at the front of the unit with DIGSI 4 or with WEB Monitor[1]. A common time tagging facilitates the comparison of events and fault records.

WEB Monitor - Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. Apart from numeric values, graphical displays in particular provide clear information and a high degree of operating reliability. Of course, it is also possible to call up detailed measured value displays and annunciation buffers. By emulation of the integrated unit operation on the PC it is also possible to adjust selected settings for commissioning purposes.

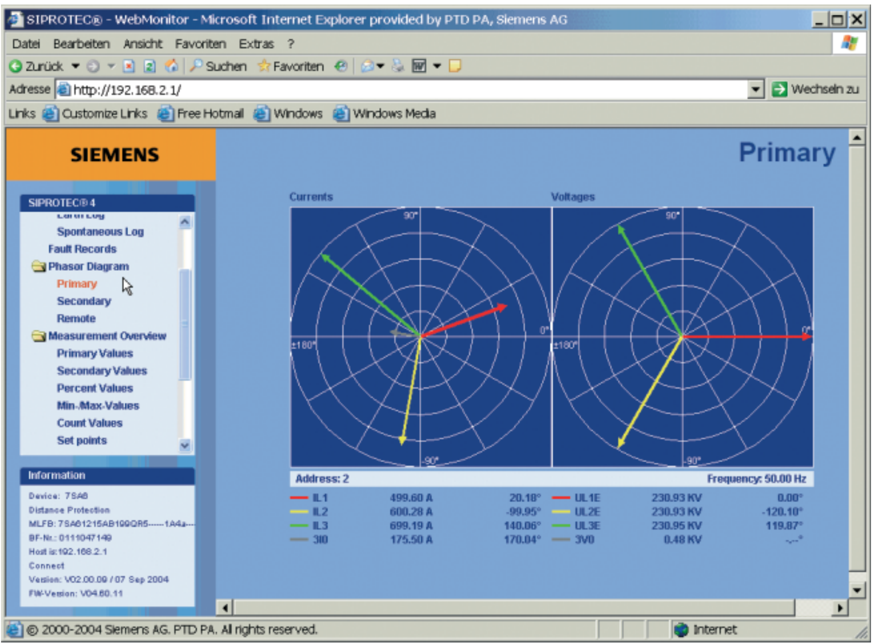


Fig. 6/17 Web Monitor: Supported commissioning by phasor diagram

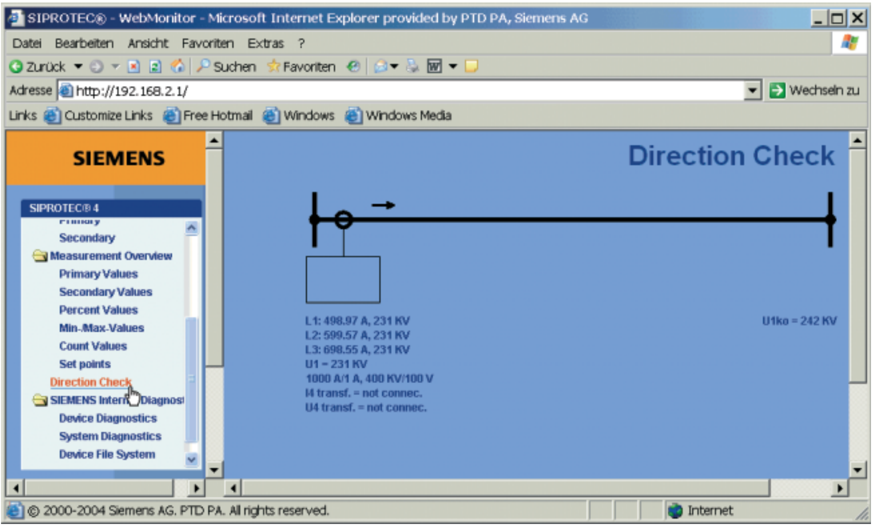


Fig. 6/18 Web Monitor: Display of the protection direction

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- Already during the process of communication, information is assigned to the cause thereof (e.g. assignment of the indication "circuit-breaker TRIP" to the corresponding command).
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the unit which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

The units offer a high degree of flexibility by supporting different standards for connection to industrial and power automation systems. By means of the communication modules, on which the protocols run, exchange and retrofit is possible. Therefore, the units will also in future allow for optimal adaptation to changing communication infrastructure such as the application of Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Local PC interface

The serial RS232 PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

7SA6 units are always fitted with a rear-side hardwired service interface, optionally as RS232 or RS485. In addition to the front-side operator interface, a PC can be connected here either directly or via a modem.

Time synchronization interface

The time synchronization interface is a standard feature in all units. The supported formats are IRIG-B and DCF77.

Reliable bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problem.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance. It is usually impossible to communicate with a unit that has failed. Should a unit fail, there is no effect on the communication with the rest of the system.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication protocols (IEC 61850, IEC 60870-5-103, PROFIBUS, DNP, etc.) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this Standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI. It will also be possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor will also provide a few items of unit-specific information in browser windows.

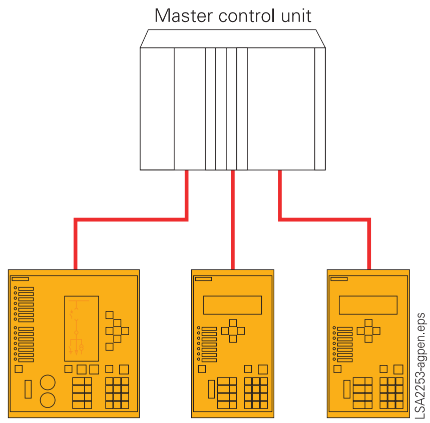


Fig. 6/19
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

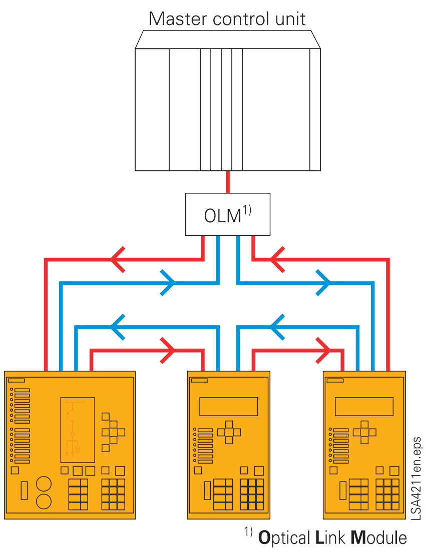


Fig. 6/20
Bus structure: Fiber-optic double ring circuit

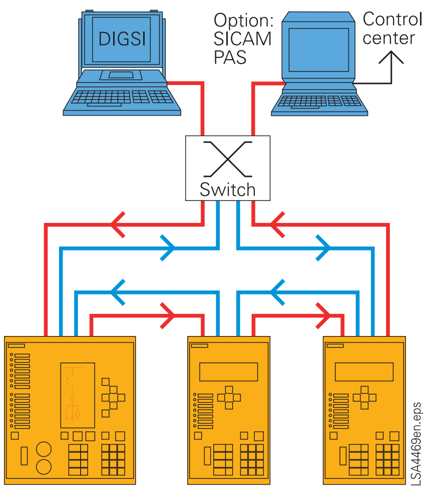


Fig. 6/21
Bus structure for station bus with Ethernet and IEC 61850

Communication

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used world-wide. Supplements for the control function are defined in the manufacturer-specific part of this standard.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized communication protocol (EN 50170). PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world. Connection to a SIMATIC programmable controller is made on the basis of the data obtained (e.g. fault recording, fault data, measured values and control functionality) via the SICAM energy automation system.

PROFIBUS-DP

PROFIBUS-DP is an industrial communications standard and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

Analog outputs 0 to 20 mA

2 or 4 analog output interfaces for transmission of measured or fault location values are available for the 7SA6. Two analog output interfaces are provided in an analog output module. Up to two analog output modules can be inserted per unit.

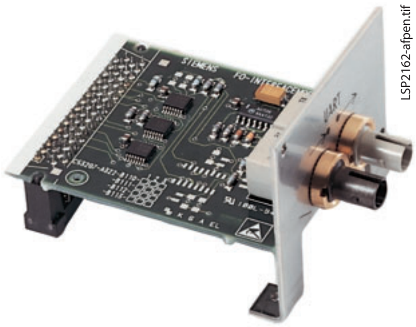


Fig. 6/22
Fiber-optic communication module

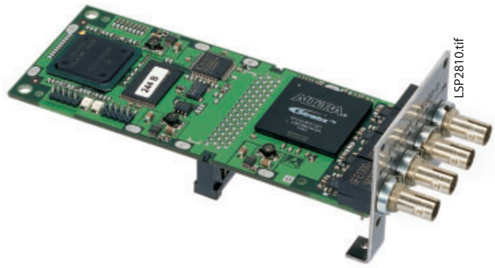


Fig. 6/23
Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

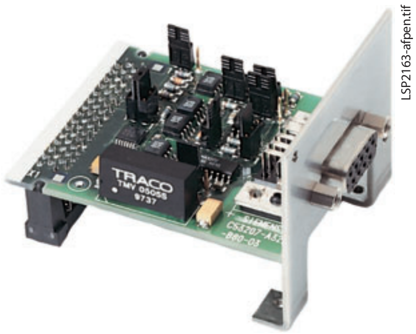


Fig. 6/24
Electrical communication module

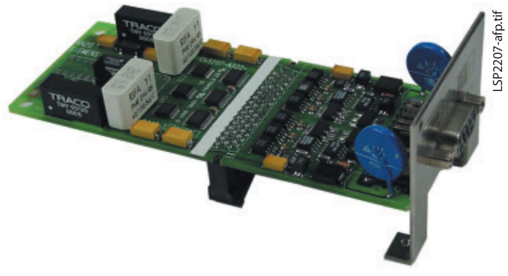


Fig. 6/25
Output module 0 to 20 mA, 2 channels

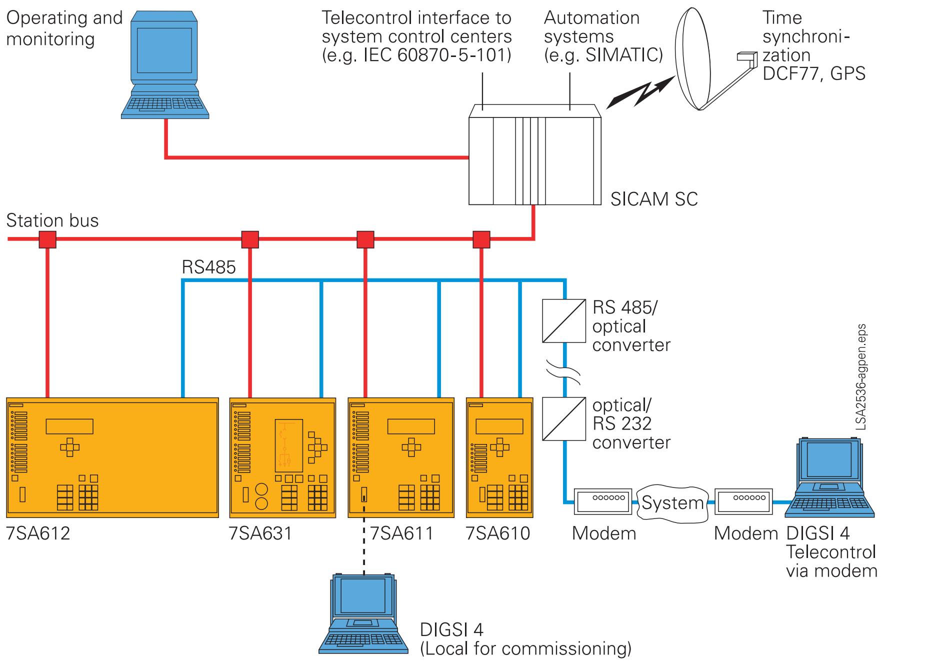


Fig. 6/26
Communication

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system. Units equipped with IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or connected in star by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 6/26).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems. Units with an IEC 60870-5-103 interface are connected with PAS via the Ethernet station bus by means of serial/Ethernet converters. DIGSI and the Web monitor can also be used via the same station bus.

Serial protection data interface

The tele (pilot) protection schemes can be implemented using digital serial communication. The 7SA6 is capable of remote relay communication via direct links or multiplexed digital communication networks. The serial protection data interface has the following features:

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Signaling for directional earth-fault protection – directional comparison for high resistance faults in solidly earthed systems
- Echo-function
- Two and three-terminal line applications can be implemented without additional logic
- Interclose command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- Redundant communication path switch over is possible with the 7SA6 when 2 serial protection data interfaces are installed
- 28 remote signals for fast transfer of binary signals
- Flexible utilisation of the communication channels by means of the programmable CFC logic
- Display of the operational measured values of the opposite terminal(s) with phase-angle information relative to a common reference vector
- Clock synchronization: the clock in only one of the relays must be synchronized from an external so called "Absolute Master" when using the serial protection data interface. This relay will then synchronize the clock of the other (or the two other relays in 3 terminal applications) via the protection data interface.
- 7SA522 and 7SA6 can be combined via the protection data interface.

The communication possibilities are identical to those for the line differential protection relays 7SD5 and 7SD610. The following options are available:

- FO5[1)], OMA1[2)] module: Optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km for link to communication networks via communication converters or for direct FO cable connection
- FO6[1)], OMA2[2)] module: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km, for direct connection via multi-mode FO cable
- FO17[1)]: For direct connection up to 25 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1)]: For direct connection up to 60 km[3)] 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1)]: For direct connection up to 100 km[3)] 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703.1 interface.

For operation via copper wire communication (pilot wires), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 15 km) and all three-wire protection systems using existing copper communication links.

Communication data:

- Supported network interfaces G703.1 with 64 kBit/s; X21/RS422 with 64 or 128 or 512 kBit/s
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC
- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.

Figure 6/27 shows four applications for the serial protection data interface on a two-terminal line.

1) For flush-mounting housing.
2) For surface-mounting housing.
3) For surface-mounting housing the internal fiber-optic module OMA1 will be delivered together with an external repeater.

6

Communication

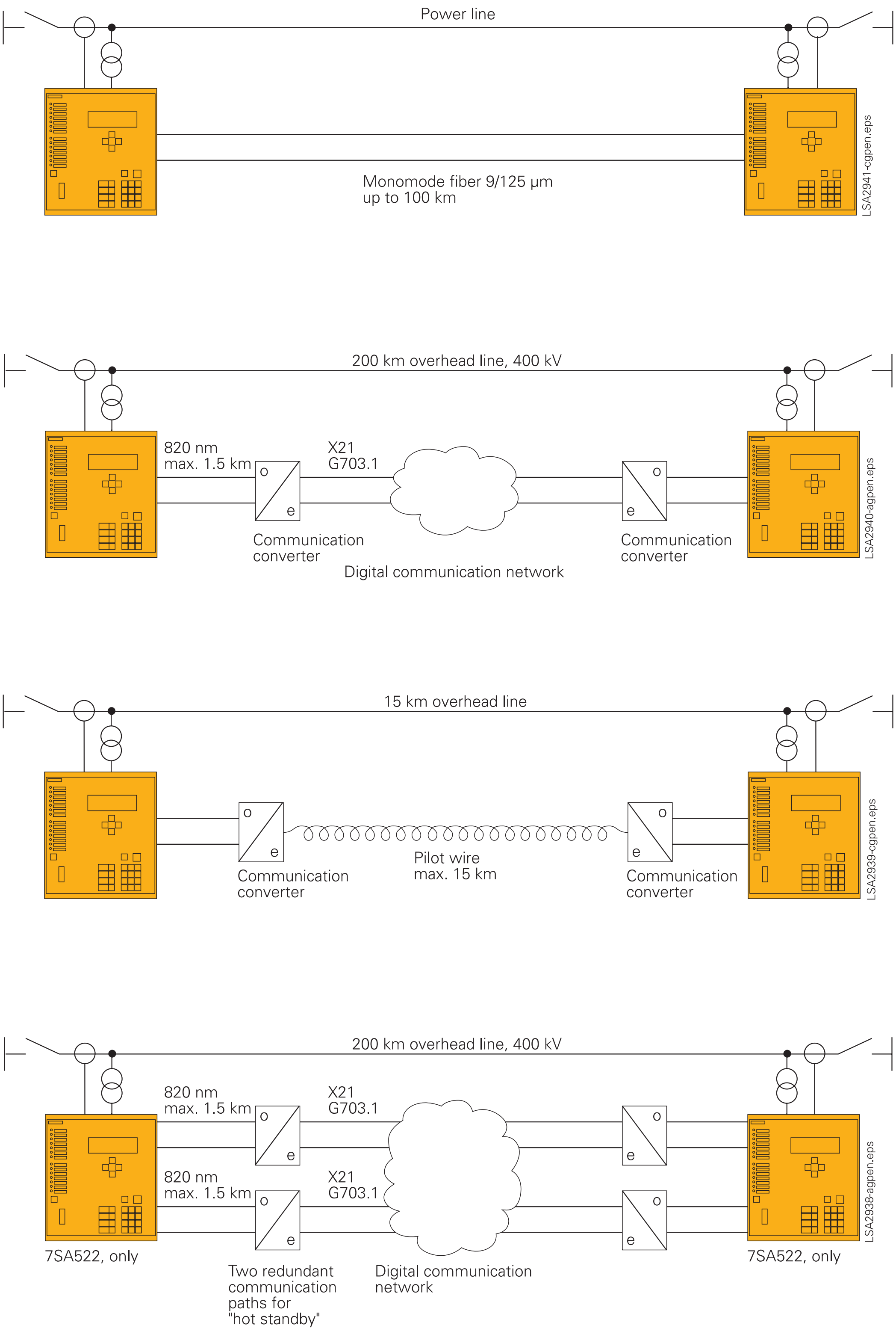


Fig. 6/27
Communication topologies for the serial protection data interface on a two-terminal line

Communication

Three-terminal lines can also be protected with a tele (pilot) protection scheme by using SIPROTEC 4 distance protection relays. The communication topology may then be a ring or a chain topology, see Fig. 6/28. In a ring topology a loss of one data connection is tolerated by the system. The topology is re-routed in a chain with less than 100 ms. To reduce communication links and to save money for communications, a chain topology may be generally applied.

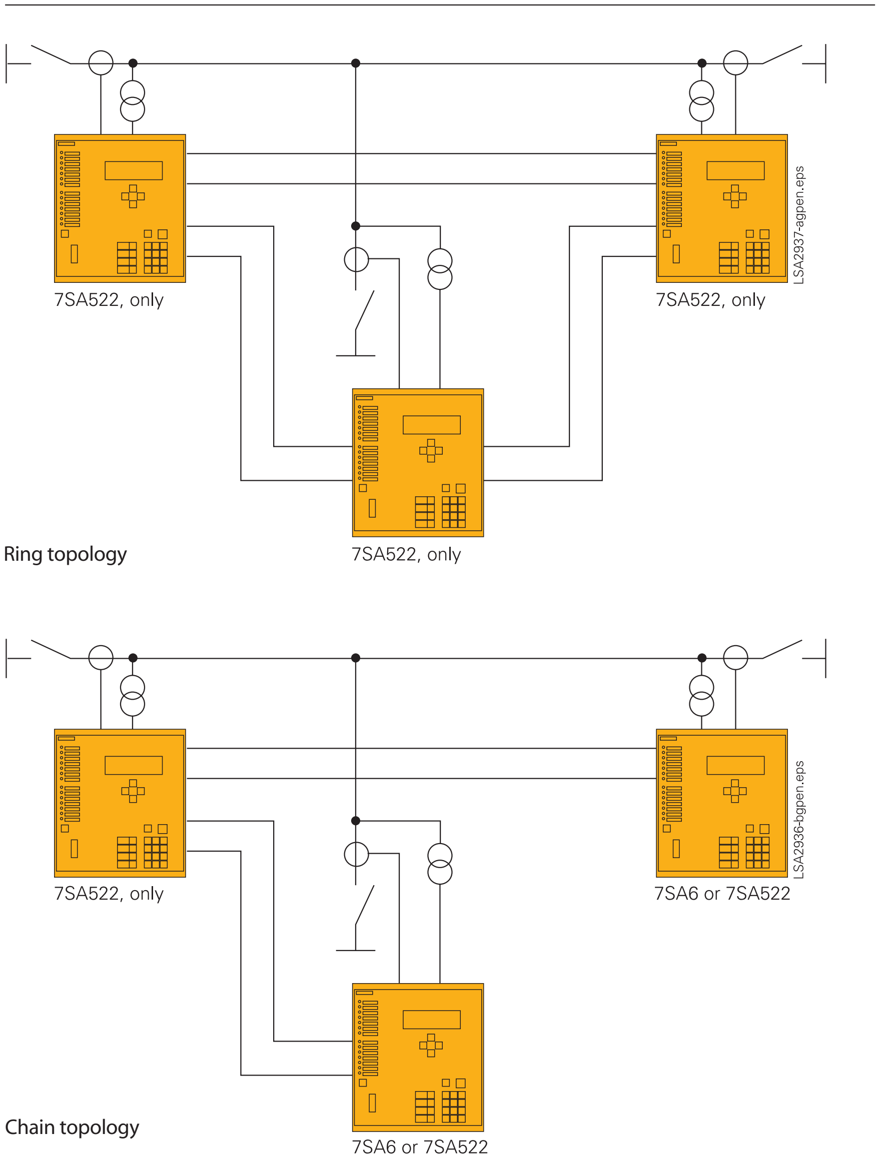


Fig. 6/28
Ring or chain communication topology

Typical connection

Connection for current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer (=$3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

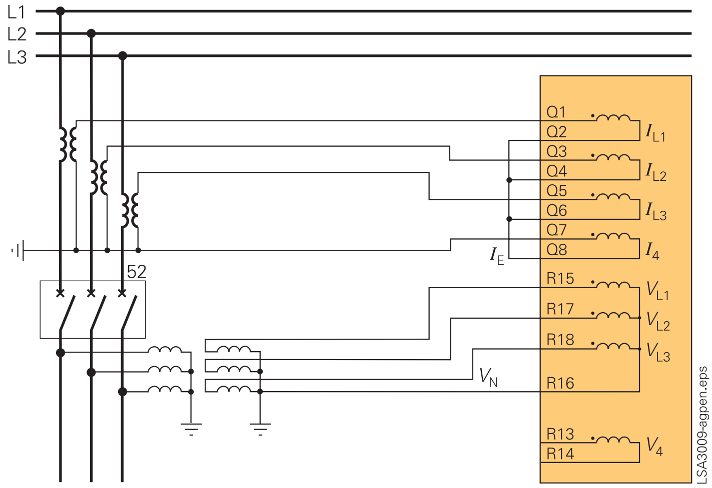


Fig. 6/29 Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 6/29, 6/33 or 6/34.

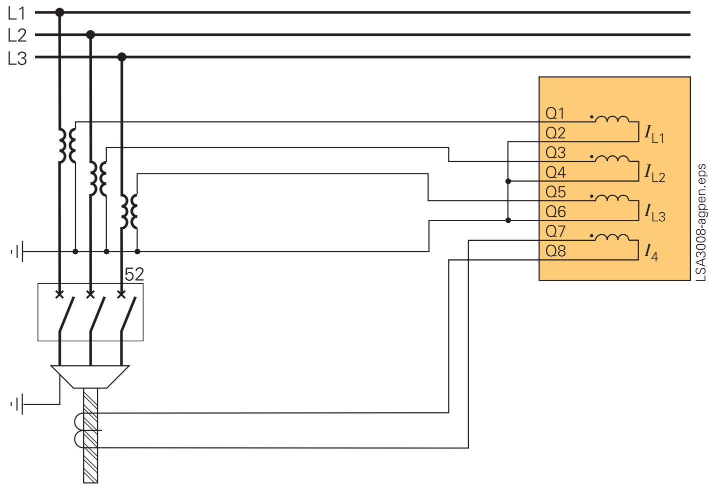


Fig. 6/30 Alternative connection of current transformers for sensitive earth-current measuring with core-balance current transformers

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of an earthed transformer for directional earth-fault protection. The voltage connection is effected in accordance with Fig. 6/29, 6/33 or 6/34.

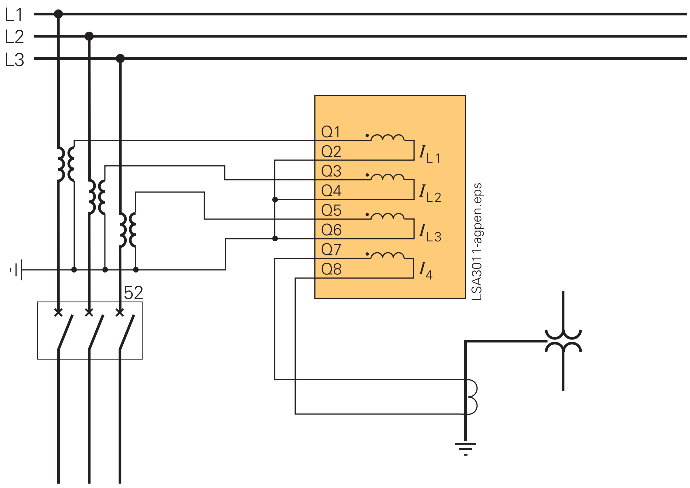


Fig. 6/31 Alternative connection of current transformers for measuring neutral current of an earthed power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 6/29, 6/33 or 6/34.

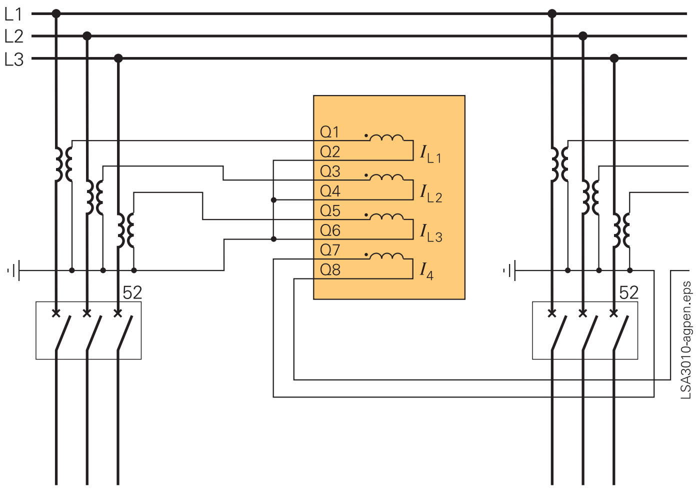


Fig. 6/32 Alternative connection of current transformers for measuring the earth current of a parallel line

Typical connection

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and earth-fault directional protection. The current connection is effected in accordance with Fig. 6/29, 6/30, 6/31 and 6/32.

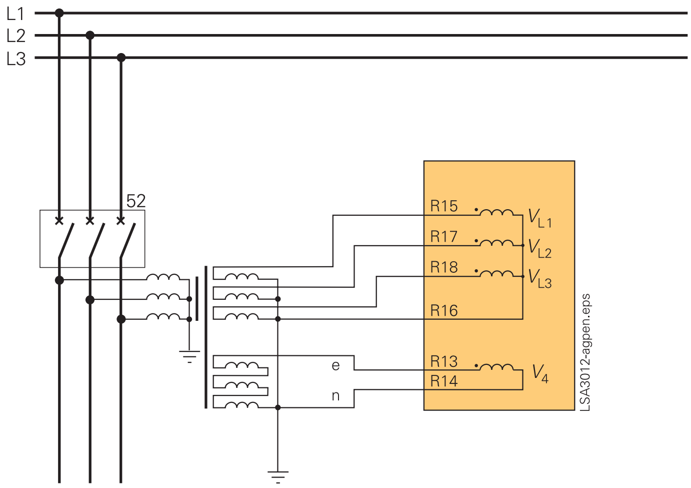


Fig. 6/33 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchro-check.

Note: Any phase-to-phase or phase-to-earth voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 6/29, 6/30, 6/31 and 6/32.

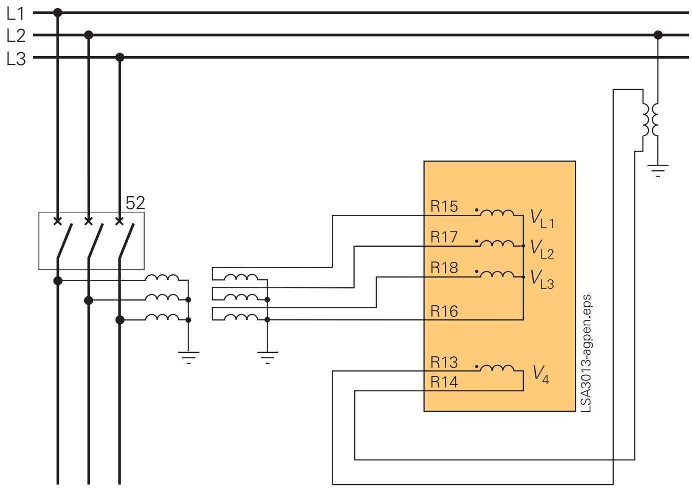


Fig. 6/34 Alternative connection of voltage transformers for measuring the busbar voltage

6

Technical data

General unit data

Analog inputs	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_{nom}	1 or 5 A (selectable)
Rated voltage V_{nom}	80 to 125 V (selectable)
Power consumption	
With I_{nom} = 1 A	Approx. 0.05 VA
With I_{nom} = 5 A	Approx. 0.30 VA
For I_E, sensitive with 1 A	Approx. 0.05 VA
Voltage inputs	≤ 0.10 VA
Overload capacity of current circuit (r.m.s.)	
Thermal	500 A for 1 s 150 A for 10 s 20 A continuous
Dynamic (peak value)	1250 A (half cycle)
Earth current	
Sensitive	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (peak value)	750 A (half cycle)
Thermal overload capacity of voltage circuit	230 V continuous
Auxiliary voltage	
Rated voltages	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V AC (50/60 Hz)
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
Quiescent	Approx. 5 W
Energized	Approx. 12 W to 18 W, depending on design
Bridging time during failure of the auxiliary voltage	
For V_{aux} = 48 V and V_{aux} ≥ 110 V	≥ 50 ms
For V_{aux} = 24 V and V_{aux} = 60 V	≥ 20 ms
Binary inputs	
Quantity	
7SA610*-*A/E/J	5
7SA610*-*B/F/K	7
7SA6*1*-*A/E/J	13
7SA6*1*-*B/F/K	20
7SA6*2*-*A/E/J	21
7SA6*2*-*B/F/K	29
7SA6*2*-*C/G/L	33
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	17 or 73 or 154 V DC, bipolar
Functions are freely assignable	
Pickup/reset voltage thresholds Ranges are settable by means of jumpers for each binary input	19 V DC/10 V DC or 88 V DC/44 V DC, or 176 V DC/88 V DC bipolar (3 nominal ranges 17/73/154 V DC)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time >60 ms

Output contacts

"Unit ready" contact (live status contact)		1 NC/NO contact[1]
Command/indication relay		
Quantity		
7SA610*-*A/E/J		5 NO contacts, 3 NC/NO contact[1]
7SA610*-*B/F/K		5 NO contacts,
7SA6*1*-*A/E/J		12 NO contacts, 4 NC/NO contacts[1]
7SA6*1*-*B/F/K		8 NO contacts, 4 power relays[2]
7SA6*2*-*A/E/J		19 NO contacts, 5 NC/NO contacts[1]
7SA6*2*-*B/F/K		26 NO contacts, 6 NC/NO contacts[1]
7SA6*2*-*C/G/L		11 NO contacts, 8 power relays[2]
<u>NO/NC contact</u>		
Switching capacity		
Make		1000 W / VA
Break, high-speed trip outputs		1000 W / VA
Break, contacts		30 VA
Break, contacts (for resistive load)		40 W
Break, contacts (for τ = L/R ≤ 50 ms)		25 VA
Switching voltage		250 V
Permissible total current		30 A for 0.5 seconds 5 A continuous
Operating time, approx.		
NO contact		8 ms
NO/NC contact (selectable)		8 ms
Fast NO contact		5 ms
High-speed NO trip outputs		< 1 ms
<u>Power relay for direct control of disconnector actuator motors</u>		
Switching capacity		
Make	for 48 to 250 V	1000 W/ VA
Break	for 48 to 250 V	1000 W/ VA
Make	for 24 V	500 W/ VA
Break	for 24 V	500 W/ VA
Switching voltage		250 V
Permissible total current		30 A for 0.5 seconds 5 A continuous
Max. operating time		30 s
Permissible relative operating time		1 %

LEDs

	Quantity
RUN (green)	1
ERROR (red)	1
LED (red), function can be assigned	
7SA610	7
7SA6*1/2/3	14

1) Can be set via jumpers.

2) Each pair of power relays is mechanically interlocked to prevent simultaneous closing.

Technical data

Unit design	
Housing	7XP20
Dimensions	Refer to part 16 f. dimension drawings
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 20 with terminal cover put on
Weight	
Flush-mounting housing 1/3 x 19"	4 kg
1/2 x 19"	6 kg
2/3 x 19"	8 kg
1/1 x 19"	10 kg
Surface-mounting housing 1/3 x 19"	6 kg
1/2 x 19"	11 kg
1/1 x 19"	19 kg

Serial interfaces	
***Operating interface for DIGSI 4** (front of unit)*	
Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1
Time synchronization	
DCF77/ IRIG-B signal (format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)
Service/modem interface for DIGSI 4 / modem / service	
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
System interface	
	IEC 61850 Ethernet IEC 60870-5-103 protocol PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 38400 baud
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Dielectric test	500 V / 50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kBd; 100 m at 12 MBd

1) For flush-mounting housing.
2) For surface mounting housing.
3) For surface mounting housing the internal fiber-optic module OMA1 will be delivered together with an external repeater.

PROFIBUS fiber-optic	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM4)
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance	500 kbit/s 1.6 km 1500 kbit/s 530 m
Protection data interface	
Quantity	1
FO51), OMA12): Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 8 dB
FO61), OMA22): Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 16 dB
FO171): for direct connection up to 25 km3), 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 13 dB
FO181): for direct connection up to 60 km3), 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB
FO191): for direct connection up to 100 km3), 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB
Relay communication equipment	
External communication converter 7XV5662-0AA00 with X21/RS422 or G703.1 interface	
External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option with clock recovery) to the X21/RS422/G703.1 interface of the communication network	Electrical X21/RS422 or G703.1 interface settable by jumper Baud rate settable by jumper
FO interface with 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode fiber to protection relay
Electrical X21/RS422 interface	64/128/512 kbit (settable by jumper) max. 800 m, 15-pin connector to the communication network
Electrical G703.1 interface	64 kbit/s max. 800 m, screw-type terminal to the communication network
External communication converter 7XV5662-0AC00 for pilot wires	
External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option with clock recovery) to pilot wires.	Typical distance: 15 km max.
FO interface for 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode fiber to protection relay, 128 kbit
Electrical interface to pilot wires	5 kV-isolated

4) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order Code L0A (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

6

6

Technical data

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) IEEE Std C37.90.0/.1/.2; UL 508 VDE 0435 Further standards see "Individual functions"
Insulation tests	
Standards	IEC 60255–5 and 60870-2-1
High-voltage test (routine test)	
All circuits except for power supply, binary inputs, high-speed outputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Auxiliary voltage, binary inputs and high-speed outputs (routine test)	3.5 kV DC
only isolated communication interfaces and time synchronization interface (routine test)	500 V (r.m.s.), 50 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 Ws, 3 positive and 3 negative impulses in intervals of 5 s
EMC tests for noise immunity; *type tests*	
Standards	IEC 60255-6/-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 part 301 DIN VDE 0435-110
High-frequency test IEC 60255-22-1 class III and VDE 0435 Section 303, class III	2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges per s; test duration 2 s, R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2 class IV and IEC 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with HF field, frequency sweep IEC 60255-22-3 (report) class III	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz
IEC 61000-4-3, class III	10 V/m; 1.4 to 2 GHz: 80 % AM; 1 kHz
Irradiation with HF field, single frequencies IEC 60255-22-31, IEC 61000-4-3, class III amplitude/pulse modulated	10 V/m; 80, 160, 450. 900 MHz; 80 % AM; 1 kHz; duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	Common mode: 2 kV; 12 Ω; 9 µF Differential mode:1 kV; 2 Ω; 18 µF
Analog measurement inputs, binary inputs, relays output	Common mode: 2 kV; 42 Ω; 0.5 µF Differential mode: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power system frequency magnetic field IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability, IEEE Std C37.90.1	2.5 kV (peak); 1 MHz τ = 50 µs; 400 surges per second, test duration 2 s, R_i = 200 Ω
Fast transient surge withstand capability, IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms repition rate 300 ms, ; both polarities; test duration 1 min; R_i = 50 Ω
Radiated electromagnetic interference IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz, amplitude and pulse-modulated
Damped oscillations IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; R_i = 200 Ω
EMC tests for noise emission; *type test*	
Standard	EN 61000-6-3 (generic standard)
Radio noise voltage to lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress test	
Vibration, shock stress and seismic vibration	
<u>During operation</u>	
Standards	IEC 60255–21 and IEC 60068–2
Oscillation IEC 60255–21–1, class 2 IEC 60068–2–6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255–21–2, class 1 IEC 60068–2–27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255–21–2, class 1 IEC 60068–3–3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Standards	IEC 60255–21 and IEC 60068–2
Oscillation IEC 60255–21–1, class 2 IEC 60068–2–6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255–21–2, class 1 IEC 60068–2–27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255–21–2, class 1 IEC 60068–2–29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Technical data

Climatic stress tests	
Standard	IEC 60255-6
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +23 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.

Functions	
Distance protection *(ANSI 21, 21N)*	
Types of pickup	Overcurrent pickup (*I*>); Voltage-dependent overcurrent pickup (*V*< / *I*>); Voltage-dependent and phase angle-dependent overcurrent pickup (*V*< / *I*> / φ>); Impedance pickup (*Z*<)
Types of tripping	Three-pole for all types of faults; Single-pole for single-phase faults / otherwise three-pole; Single-pole for single-phase faults and two-pole phase-to-phase faults / otherwise three-pole
Characteristic	Quadrilateral or circle
Distance protection zones	6, 1 of which as controlled zone All zones can be set to forward, reverse, non-directional or inactive
Timer stages for tripping delay	6 for multi-phase faults 3 for single-phase faults
Setting range	0 to 30 s or deactivated (steps 0.01 s)
Zone setting X (for distance zones and Z< starting)	0.050 to 600 Ω (1A) / 0.01 to 120 Ω (5A) (step 0.001 Ω)
Resistance setting (for quadrilateral distance zones and Z< starting)	
Phase-to-phase faults and phase-to-earth faults	0.05 to 600 Ω (1A) / 0.01 to 120 Ω (5A) (step 0.001 Ω)
Line angle	10 ° to 89 °
Inclination angle for quadrilateral characteristic	30° to 90° (step 1°)
Zone setting Z_r (for circle characteristic)	0.050 to 600 Ω(1 A)/0.010 to 120 Ω(5 A) (step 0.001 Ω)
Threshold angle α for increased resistance tolerance (circle charac.)	10 to 90 ° (step 1°)
Overcurrent pickup *I*>> (for *I*>>, *V*</*I*>, *V*</*I*>/φ>)	0.25 to 10 A (1A) / 1.25 to 50 A (5A) (step 0.01 A)
Minimum current pickup *I*> (for *V*</*I*>, *V*</*I*>/φ> and *Z*<)	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Minimum current pickup $I_φ$> (for *V*</*I*>, *V*</*I*>/φ>)	0.1 to 8 A (1A) / 0.5 to 40 A (5A) (step 0.01 A)
Undervoltage pickup (for *V*</*I*> and *V*</*I*>/φ>)	
V_{PH-e}<	20 to 70 V (step 1 V)
V_{PH-PH}<	40 to 130 V (step 1 V)
Load angle pickup (for *V*</*I*>/φ>)	
Load angle φ	30 ° to 80 °
Load angle *φ*	90 ° to 120 °
Load zone (for *Z*<)	Impedances within the load zone do not cause pickup in pickup mode Z<; Load zones for phase-to-phase and phase-to-earth faults can be set separately
Load angle	20 ° to 60 °
Resistance	0.1 to 600 Ω (1A) / 0.02 to 120 Ω (5A)
Earth-fault detection	
Earth current $3I_0$>	0.05 to 4 A (1A) / 0.25 A to 20 A (5A) (step 0.01 A)
Zero-sequence voltage $3V_0$>	
for earthed networks	1 to 100 V (step 1 V) or deactivated
for resonant-earthed networks	10 to 200 V (step 1 V)
Earth impedance matching	
Parameter formats	R_E/R_L and X_E/X_L or k_0 and φ (k_0)
Separately settable for	Distance protection zone Z1 and higher distance zones (Z1B, Z2 to Z5)
R_E/R_L and X_E/X_L	-0.33 to +7.00 (step 0.01)
k_0 and φ (k_0)	0 to 4 (step 0.01) and - 135 ° to 135 ° (step 0.01 °)
Parallel line matching	For parallel compensation
R_M/R_L and X_M/X_L	0 to 8 (step 0.01)
Phase preference on double earth-faults in resonant-earthed / non-earthed networks	Phase preference or no preference (selectable)
Direction decision for all types of faults	With fault-free voltages and/or voltage memory
Direction sensitivity	Dynamically unlimited

6

Technical data

Times	
Shortest trip time (measured at the fast relay; refer to the terminal connection diagram)	Approx. 17 ms for $f_N = 50$ Hz Approx. 15 ms for $f_N = 60$ Hz
Shortest trip time (measured at the high-speed trip outputs)	Approx. 12 ms at 50 Hz Approx. 10 ms at 60 Hz
Reset time	Approx. 30 ms
Tolerances	For sinusoidal measured variables
Response values (in conformity with DIN 57435, Part 303) V and I Angle (φ)	 ≤ 5 % of setting value ≤ 3 °
Impedances (in conformity with DIN 57435, Part 303)	$\left\|\frac{\Delta X}{X}\right\| \le 5\,\%$ for $30° \le \varphi_{SC} \le 90°$ $\left\|\frac{\Delta R}{R}\right\| \le 5\,\%$ for $0° \le \varphi_{SC} \le 60°$
Time stages	1 % of setting value or 10 ms
Fault locator	
Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or in % of line length
Start of calculation	With trip, with reset of pickup, with binary input
Reactance per unit length	0.005 to 6.5 Ω/km$_{(1A)}$ / 0.001 to 1.3 Ω/km$_{(5A)}$ (step 0.001 Ω/km)
Tolerance	For sinusoidal quantities ≤ 2.5 % line length for $30° \le \varphi_{SC} \le 90°$ and $V_{SC}/V_{nom} > 0.1$
BCD-coded output of fault location	
Indicated value	Fault location in % of the line length
Output signals	Max. 10: d[1 %], d[2 %], d[4 %], d[8 %], d[10 %], d[20 %], d[40 %], d[80 %], d[100 %], d[release]
Indication range	0 % to 195 %
Tele (pilot) protection for distance protection *(ANSI 85-21)*	
Modes of operation	PUTT (Z1B acceleration); DUTT; PUTT (acceleration with pickup); POTT; Directional comparison; Reverse interlocking Pilot-wire comparison; Unblocking; Blocking
Additional functions	Echo function (refer to weak-infeed function) Transient blocking for schemes with measuring range extension
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2- and 3-end-lines

Weak-infeed protection *(ANSI 27-WI)*	
Operating modes with carrier (signal) reception and no fault detection	Echo Echo and trip with undervoltage
Undervoltage phase-earth	2 to 70 V (step 1 V)
Time delay	0 to 30 s (step 0.01 s)
Echo impulse	0 to 30 s (step 0.01 s)
Tolerances Voltage threshold Timer	 ≤ 5 % of setting value or 0.5 V 1 % of setting value or 10 ms
Direct transfer trip (DTT)	
Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure
Trip time delay	0 to 30 s (step 0.01 s)
Timer tolerance	1 % of setting value or 10 ms
Power swing detection *(ANSI 68, 68T)*	
Power swing detection principle	Measurement of the rate of change of the impedance vector and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping for out-of-step conditions
Power swing blocking programs	All zones blocked; Z1/Z1B blocked; Z2 to Z5 blocked; Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults
Backup overcurrent protection *(ANSI 50 (N), 51 (N), 67)*	
Operating modes	Active only with loss of VT secondary circuit or always active
Characteristic	2 definite-time stages / 1 inverse-time stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Definite-time stage *(ANSI 50, 50N)*	
Phase current pickup I_{PH}>>	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A)
Earth current pickup $3I_0$>>	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A)
Phase current pickup I_{PH}>	0.1 to 25 A $_{(1A)}$ / 0.5 to 125 A $_{(5A)}$ (step 0.01 A)
Earth current pickup $3I_0$>	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A)
Time delay	0 to 30 s (step 0.01 s) or deactivated
Tolerances Current pickup Delay times	 ≤ 3 % of setting value or 1 % I_N 1 % of setting value or 10 ms
Operating time	Approx. 25 ms

Technical data

Inverse-time stage *(ANSI 51, 51N)*

Phase current pickup I_P	0.1 to 4 A (1A) / 0.5 to 20 A (5A) (step 0.01 A)
Earth current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Tripping time characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time inverse
Tripping time characteristics acc. to ANSI/IEEE (not for DE region, see selection and ordering data 10th position)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Time multiplier for IEC charac. T	T_p = 0.05 to 3 s (step 0.01 s)
Time multiplier for ANSI charac. D	D_{IP} = 0.5 to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 I/I_p (ANSI: I/I_p = M)
Reset threshold	Approx. 1.05 x I/I_p (ANSI: I/I_p = M)
Tolerances Operating time for $2 \leq I/I_p \leq 20$	 ≤ 5 % of setpoint ± 15 ms

Directional earth-fault overcurrent protection for high-resistance faults in systems with earthed star point *(ANSI 50N, 51N, 67N)*

Characteristic	3 definite-time stages / 1 inverse-time stage or 4 definite-time stages or 3 definite-time stages / 1 $V_{0invers.}$ stage
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults selectable for every stage
Inrush restraint	Selectable for every stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Influence of harmonics Stages 1 and 2 (I>>> and I>>)	 3rd and higher harmonics are completely suppressed by digital filtering
Stages 3 and 4 (I> and inverse 4th stage)	2nd and higher harmonics are completely suppressed by digital filtering

Definite-time stage *(ANSI 50N)*

Pickup value $3I_0$>>>	0.5 to 25 A (1A) / 2.5 to 125 A (5A) (step 0.01 A)
Pickup value $3I_0$>>	0.2 to 25 A (1A) / 1 to 125 A (5A) (step 0.01 A)
Pickup value $3I_0$>	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A (1A) / 0.015 to 125 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Pickup value $3I_0$, 4th stage	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A (1A) / 0.015 to 125 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Time delay for definite-time stages	0 to 30 s (step 0.01 s) or deactivated
Tolerances Current pickup Delay times	 ≤ 3 % of setting value or 1 % I_{nom} 1 % of setting value or 10 ms
Command / pickup times $3I_0$>>> and $3I_0$>>	Approx. 30 ms
Command / pickup times $3I_0$> and $3I_0$, 4th stage	Approx. 40 ms

Inverse-time stage *(ANSI 51N)*

Earth-current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7) 0.003 to 4 A (1A) / 0.015 to 20 A (5A) (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Tripping characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time
ANSI/IEEE tripping characteristic (not for region DE, see selection and ordering data, position 10)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Inverse logarithmic tripping characteristics (not for regions DE and US, see selection and ordering data, position 10)	$t = T_{3I0Pmax} - T_{3I0P} \ln \frac{3I0}{3I0_p}$
Pickup threshold	1.1 to 4.0 x I/I_p (step 0.1 s)
Time multiplier for IEC charac. T	T_p = 0.05 to 3 s (step 0.01 s)
Time multiplier for ANSI charac. D	D_{I0P} = 0.5 to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 I/I_p (ANSI: I/I_p = M)
Inverse logarithmic pickup threshold	1.1 to 4.0 x I/I_{0P} (step 0.1)
Reset threshold	Approx. 1.05 I/I_{0P} (ANSI: I/I_p = M)
Tolerance Operating time for $2 \leq I/I_p \leq 20$	 ≤ 5 % of setpoint ± 15 ms

Zero-sequence voltage protection $V_{0inverse}$

Tripping characteristic	$t = \dfrac{2\text{ s}}{\frac{V_0}{4} - V_{0\text{inv min}}}$

Zero-sequence power-dependent stage

Compensated zero-sequence power	$S_r = 3I_0 \cdot 3V_0 \cdot \cos(\varphi - \varphi_{comp.})$

Direction decision *(ANSI 67N)*

Measured signals for direction decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_Y (star point current of an earthed power transformer) or $3I_2$ and $3V_2$ (negative-sequence system) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Min. current I_Y (of earthed transformers)	0.05 to 1 A (1A) / 0.25 to 5 A (5A) (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A (1A) / 0.25 to 5 A (5A) (step 0.01 A)

Technical data

Inrush current blocking, capable of being activated for each stage	
Component of the 2nd harmonic	10 to 45 % of the fundamental (step 1 %)
Max. current, which cancels inrush current blocking	0.5 to 25 A (1A) / 2.5 to 125 A (5A) (step 0.01 A)
Tele (pilot) protection	
For directional earth-fault protection *(ANSI 85-67N)*	
Operating modes	Directional comparison, blocking, unblocking
Additional functions	Echo (see function “weak infeed”); transient blocking for schemes with parallel lines
Send and receive signals	Suitable for 2 and 3 end-lines
Instantaneous high-speed switch-onto-fault overcurrent protection *(ANSI 50HS)*	
Operating mode	Active only after CB closing; instantaneous trip after pickup
Pickup current I>>>	1 to 25 A (1A) / 5 to 125 A (5A) (step 0.01 A)
Reset ratio	Approx. 0.90
Tolerances Current starting	 ≤ 3 % of setting value or 1 % I_N
Shortest tripping time With reference to fast relays With high-speed trip to outputs	 Approx. 12 ms Approx. 8 ms
Voltage protection *(ANSI 59, 27)*	
Operating modes	Local tripping and/or carrier trip for remote end
Overvoltage protection	
Pickup values V_{PH-E}>>, V_{PH-E}> (phase-earth overvoltage)	1 to 170 V (step 0.1 V)
Pickup values V_{PH-PH}>>, V_{PH-PH}> (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $3V_0$>>, $3V_0$> ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Pickup values V_1>>, V_1> (positive-sequence overvoltage) Measured voltage	2 to 220 V (step 0.1 V) Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values V_2>>, V_2> (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values V_{PH-E}<<, V_{PH-E}< (phase-earth undervoltage)	1 to 100 V (step 0.1 V)
Pickup values V_{PH-PH}<<, V_{PH-PH}< (phase-phase undervoltage)	1 to 170 V (step 0.1 V)
Pickup values V_1<<, V_1< (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)
Blocking of undervoltage prot. stages	Minimum current; binary input
Reset ratio (settable)	1.01 to 1.20 (step 0.01)

Time delays	
Time delay for all stages	0 to 100 s (step 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Command/pickup time for $3V_0$ stages	Approx. 30 ms or 65 ms (settable)
Tolerances Voltage limit values Time stages	 ≤ 3 % of setting value or 1 V 1 % of setting value or 10 ms
Frequency protection *(ANSI 81)*	
Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-earth)
Pickup times	Approx. 80 ms
Dropout times Hysteresis Dropout condition	Approx. 80 ms Approx. 20 mHz Voltage = 0 V and current = 0 A
Tolerances Frequency Delay times	 15 mHz for V_{PH-PH}: 50 to 230 V 1 % of the setting value or 10 ms
Thermal overload protection *(ANSI 49)*	
Factor k acc. to IEC 60255-8	0.1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{Alarm}/\Theta_{Trip}$	50 to 100 % referred to tripping temperature (steps 1 %)
Current-based alarm stage I_{Alarm}	0.1 to 4 A (1A) / 0.5 to 20 A (5A) (steps 0.01 A)
Calculating mode for overtemperature	Θ_{max}, Θ_{mean}, Θ with I_{max}
Pickup time characteristic	$t = \tau \ln \frac{I^2 - I_{pre}^2}{I^2 - (k\, I_{nom})^2}$
Reset ratio Θ/Θ_{Alarm} Θ/Θ_{Trip} I/I_{Alarm}	 Approx. 0.99 Approx. 0.99 Approx. 0.97
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}
Tolerances	Class 10 % acc. to IEC 60255-8
Breaker failure protection *(ANSI 50BF)*	
Number of stages	2
Pickup of current element	0.05 to 20 A (1A) / 0.25 to 100 A (5A) (step 0.01 A)
Time delays $T1_{1phase}$, $T1_{3phase}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection CB pole discrepancy monitoring
Drop-off (overshoot) time, internal	≤ 15 ms, typical; 25 ms, max.
Tolerances Current limit value Time stages	 ≤ 5 % of setting value or 1 % I_{nom} 1 % of setting value or 10 ms

Technical data

***Auto-reclosure** (ANSI 79)*	
Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1 or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T_{1\text{-PH}}$, $T_{3\text{-PH}}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT Healthy line voltage $_{\text{PH-E}}$ Dead line voltage $_{\text{PH-E}}$	 30 to 90 V (step 1 V) 2 to 70 V (step 1 V)
Tolerances Time stages Voltage limit values	 1 % of setting value or 10 ms ≤ 3 % of setting value or 1 V
***Synchro-check** (ANSI 25)*	
Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes With auto-reclosure	 Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1°)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Minimum measuring time	Approx. 80 ms
Tolerances Time stages Voltage limit values	 1 % of setting value or 10 ms ≤ 2 % of setting value or 1 V
Earth-fault detection for compensated / isolated networks	
Zero-sequence voltage $3V_0$	1 to 150 V (step 1 V)
Phase selection with phase voltages $V<$ and $V>$	10 to 100 V (step 1 V)
Directional determination	Active / reactive power measurements
Minimum current for directional determination	3 to 1000 mA (steps 1 mA)
Angle correction for core-balance CT	0 to 5 ° at 2 operating points (step 0.1 °)
Operating modes	Only indication; indication and trip
Delay times	0 to 320 s (step 0.01 s)
Pickup time	Approx. 50 ms
Earth-fault measured values	Active and reactive component of earth-fault current I_{EEac}, I_{EEreac}
Tolerances Voltage limit values Current limit values Time stages	 ≤ 5 % of setting value or 1 V ≤ 10 % of setting value 1 % of setting value or 10 ms
***Trip circuit supervision** (ANSI 74TC)*	
Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Additional functions	
Operational measured values	
Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; $I_{E\ sensitve}$; I_1; I_2; I_Y; $3I_{0PAR}$
Tolerances	Typ. 0.3 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{Phase\text{-}Earth}$; 3 x $V_{Phase\text{-}Phase}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}
Tolerances	Typ. 0.25 % of indicated measured value or 0.01 % V_{nom}
Power with direction indication	P, Q, S
Tolerances P: for $\lvert\cos\varphi\rvert$ = 0.7 to 1 and V/V_{nom}, I/I_{nom} = 50 to 120 % Q: for $\lvert\sin\varphi\rvert$ = 0.7 to 1 and V/V_{nom} , I/I_{nom} = 50 to 120 % S: for V/V_{nom}, I/I_{nom} = 50 to 120 %	 Typical ≤ 1% Typical ≤ 1% Typical ≤ 1%
Frequency Tolerance	f ≤ 10 mHz
Power factor	p.f. (cos φ)
Tolerance for $\lvert\cos\varphi\rvert$ = 0.7 to 1	Typical ≤ 0.02
Load impedances with directional indication	3 x $R_{Phase\text{-}Earth}$, $X_{Phase\text{-}Earth}$ 3 x $R_{Phase\text{-}Phase}$, $X_{Phase\text{-}Phase}$
Earth-fault measured values	Active and reactive component of earth-fault current I_{EEac}, I_{EEreac}
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}
Long-term mean values	
Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every ¼ hour; every ½ hour; every hour
Values	3 x I_{Phase}; I_1; P; P+; P-; Q; Q+; Q-; S

6

Technical data

Minimum/maximum memory	
Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values Min./max. of measured values	 3 x I_{Phase}; I_1; 3 x $V_{Phase-Earth}$; 3 x $V_{Phase-to-phase}$; $3V_0$; V_1; P+; P-; Q+; Q-; S; f; power factor (+); power factor (–)
Min./max. of mean values	3 x I_{Phase}; I_1; P; Q; S
Energy meters	
Four-quadrant meters	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance for $\lvert\cos\varphi\rvert > 0.7$ and $V >$ 50 % V_{nom} and $I >$ 50 % I_{nom}	 5 %
Analog measured value output 0 to 20 mA	
Number of analog channels	2 per plug-in module Alternatively 1 or 2 or no plug-in module (Refer to ordering data, position 11 and Order code for position 12)
Indication range	0 to 22 mA
Selectable measured values	Fault location [%]; fault location [km]; V_{L23} [%]; I_{L2} [%]; $\lvert P\rvert$ [%]; $\lvert Q\rvert$ [%]; breaking current $I_{max-primary}$
Max. burden	350 Ω
Oscillographic fault recording	
Analog channels	3 x I_{Phase}, $3I_0$, $3I_{0\,PAR}$ 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	> 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	40
Control	
Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys, control keys (if available)
Remote control	Control protection, DIGSI, pilot wires

Further additional functions	
Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Phase sequence Fuse failure monitor Power direction
Indications Operational indications	 Buffer size 200
System disturbance indication	Storage of indications of the last 8 faults, buffer size 600
Earth-fault indication	Storage of indications of the last 8 faults, buffer size 200
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE per phase
Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Commissioning support	Operational measured values, c.-b. test, status display of binary inputs, setting of output relays, generation of indications for testing serial interfaces
Phase rotation adjustment	Clockwise or anti-clockwise

CE conformity

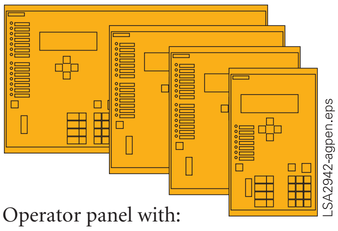
This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data



Operator panel with:
- 4-line backlit display,
- function keys,
- numerical keys,
- PC interface

Description	Order No.
7SA61 distance protection relay for all voltage levels	*7SA61□□-□□□□□-□□□□*

see pages 6/32 to 6/35

Housing, number of LEDs	
Housing width 1/3 19", 7 LEDs	*0*
Housing width 1/2 19", 14 LEDs	*1*
Housing width 1/1 19", 14 LEDs	*2*
Housing width 2/3 19", 14 LEDs	*3*

Measuring input (4 x V, 4 x I)	
I_{PH} = 1 A[1)], I_e = 1 A (min. = 0.05 A)	*1*
I_{PH} = 1 A[1)], I_e = sensitive (min. = 0.003 A)	*2*
I_{PH} = 5 A[1)], I_e = 5 A (min. = 0.25 A)	*5*
I_{PH} = 5 A[1)], I_e = sensitive (min. = 0.003 A)	*6*

Rated auxiliary voltage (power supply, binary inputs)	
24 to 48 V DC, binary input threshold 17 V[3)]	*2*
60 to 125 V DC[2)], binary input threshold 17 V[3)]	*4*
110 to 250 V DC[2)], 115 V AC, binary input threshold 73 V[3)]	*5*

Binary/ indication inputs	Indication/ command outputs incl. live status contact	Fast relay[4)]	High-speed trip output	Power relay[5)]	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	Surface-mounting housing/ screw-type terminals	
For 7SA610								
5	9				■			*A*
5	9						■	*E*
5	9					■		*J*
7	6				■			*B*
7	6						■	*F*
7	6					■		*K*
For 7SA611								
13	10	7			■			*A*
13	10	7					■	*E*
13	10	7				■		*J*
13	9	3	5		■			*M*
13	9	3	5				■	*N*
13	9	3	5			■		*P*
20	9			4	■			*B*
20	9			4			■	*F*
20	9			4		■		*K*
For 7SA612								
21	18	7			■			*A*
21	18	7					■	*E*
21	18	7				■		*J*
21	17	3	5		■			*M*
21	17	3	5				■	*P*
21	17	3	5			■		*R*
29	26	7			■			*B*
29	26	7					■	*F*
29	26	7				■		*K*
29	25	3	5		■			*N*
29	25	3	5				■	*Q*
29	25	3	5			■		*S*
33	12			8	■			*C*
33	12			8			■	*G*
33	12			8		■		*L*
For 7SA613								
21	18	7			■			*A*
21	17	3	5		■			*M*

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

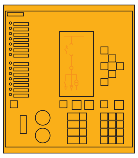
3) The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary input thresholds.

4) Fast relays are identified in the terminal connection diagram.

5) Power relay for direct control of disconnector actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

6

Selection and ordering data



LSA2539-agpen.eps

Operator panel with:
- backlit graphic display for single-line diagram
- control keys,
- key-operated switches,
- function keys,
- numerical keys,
- PC interface

Description	Order No.
7SA63 distance protection relay for all voltage levels	*7SA63□□-□□□□□-□□□□*
Housing, number of LEDs	
Housing width 1/2 19", 14 LEDs	*1*
Housing width 1/1 19", 14 LEDs	*2*
Measuring input (4 x V, 4 x I)	
I_{PH} = 1 A[1], I_e = 1 A (min. = 0.05 A)	*1*
I_{PH} = 1 A[1], I_e = sensitive (min. = 0.003 A)	*2*
I_{PH} = 5 A[1], I_e = 5 A (min. = 0.25 A)	*5*
I_{PH} = 5 A[1], I_e = sensitive (min. = 0.003 A)	*6*
Rated auxiliary voltage (power supply, binary inputs)	
24 to 48 V DC, binary input threshold 17 V[3]	*2*
60 to 125 V DC[2], binary input threshold 17 V[3]	*4*
110 to 250 V DC[2], 115 V AC, binary input threshold 73 V[3]	*5*

see pages 6/32 to 6/35

Binary/ indication-inputs	Indication/ command outputs incl. live status contact	Fast relay[4]	High-speed trip outputs	Power relay[5]	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	Surface-mounting housing/ screw-type terminals	
For 7SA631								
13	10	7			■			*A*
13	10	7					■	*E*
13	10	7				■		*J*
13	9	3	5		■			*M*
13	9	3	5				■	*N*
13	9	3	5			■		*P*
20	9			4	■			*B*
20	9			4			■	*F*
20	9			4		■		*K*
For 7SA632								
21	18	7			■			*A*
21	18	7					■	*E*
21	18	7				■		*J*
21	17	3	5		■			*M*
21	17	3	5				■	*P*
21	17	3	5			■		*R*
29	26	7			■			*B*
29	26	7					■	*F*
29	26	7				■		*K*
29	25	3	5		■			*N*
29	25	3	5				■	*Q*
29	25	3	5			■		*S*
33	12			8	■			*C*
33	12			8			■	*G*
33	12			8		■		*L*

1) Rated current can be selected by means of jumpers.

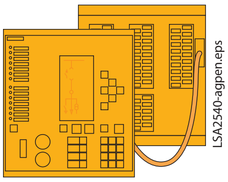
2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary inputs thresholds.

4) Fast relays are identified in the terminal connection diagram.

5) Power relay for direct control of disconnector actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

Selection and ordering data



Units with
detached operator panel with
- backlit graphic display
- control keys
- key-operated switches
- function keys
- numerical keys
- PC interface

Description	Order No.
7SA64 distance protection relay for all voltage levels	*7SA64□□-□□□□□-□□□□*
	see pages 6/32 to 6/35
Housing, number of LEDs	
Housing width 1/2 19", 14 LEDs	*1*
Housing width 1/1 19", 14 LEDs	*2*
Measuring input (4 x V, 4 x I)	
I_{PH} = 1 A[1)], I_e = 1 A (min. = 0.05 A)	*1*
I_{PH} = 1 A[1)], I_e = sensitive (min. = 0.003 A)	*2*
I_{PH} = 5 A[1)], I_e = 5 A (min. = 0.25 A)	*5*
I_{PH} = 5 A[1)], I_e = sensitive (min. = 0.003 A)	*6*
Rated auxiliary voltage (power supply, binary inputs)	
24 to 48 V DC, binary input threshold 17 V[3)]	*2*
60 to 125 V DC[2)], binary input threshold 17 V[3)]	*4*
110 to 250 V DC[2)], 115 V AC, binary input threshold 73 V[3)]	*5*

Binary/ indication inputs	Indication/ command outputs incl. live status contact	Fast relay[4)]	High-speed trip outputs	Power relay[5)]	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	
For 7SA641							
13	10	7			■		*A*
13	10	7				■	*J*
13	9	3	5		■		*M*
13	9	3	5			■	*P*
20	9			4	■		*B*
20	9			4		■	*K*
For 7SA642							
21	18	7			■		*A*
21	18	7				■	*J*
21	17	3	5		■		*M*
21	17	3	5			■	*R*
29	26	7			■		*B*
29	26	7				■	*K*
29	25	3	5		■		*N*
29	25	3	5			■	*S*
33	12			8	■		*C*
33	12			8		■	*L*

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds are selectable in three stages by means of jumpers, exception: versions with power relays have some binary inputs with only two binary inputs thresholds.

4) Fast relays are identified in the terminal connection diagram.

5) Power relay for direct control of disconnector actuator motors. Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

Selection and ordering data

Description	Order No.	Order code
7SA6 distance protection relay for all voltage levels	*7SA6□□□-□□□□□-□□□□*	*□□□*
Region-specific default settings / language settings[1)]		
Region DE, language: German; selectable	*A*	
Region World, language: English (GB)	*B*	
Region US, language: English (US)	*C*	
Region FR, French	*D*	
Region World, Spanish	*E*	
Region World, Italian	*F*	
Port B		
Empty	*0*	
System interface, IEC 60870-5-103 protocol, electrical RS232	*1*	
System interface, IEC 60870-5-103 protocol, electrical RS485	*2*	
System interface, IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
System interface, PROFIBUS-FMS Slave[2)], electrical RS485	*4*	
System interface, PROFIBUS-FMS Slave[2)], optical [3)], double ring [3)], ST connector	*6*	
2 analog outputs, each 0.....20 mA	*7*	
System interface, PROFIBUS-DP, electrical RS485	*9*	*L 0 A*
System interface, PROFIBUS-DP, optical 820 nm, double ring [3)], ST connector	*9*	*L 0 B*
System interface, DNP 3.0, electrical RS485	*9*	*L 0 G*
System interface, DNP 3.0, optical 820 nm, ST connector[3)]	*9*	*L 0 H*
System interface, IEC 61850, 100 Mbit/s Ethernet, electrical, duplicate, RJ45 plug connectors	*9*	*L 0 R*
System interface, IEC 61850, 100 Mbit/s Ethernet, optical, double, ST connector[4)]	*9*	*L 0 S*

see pages 6/33 to 6/35

1) Definitions for region-specific default settings and functions:

Region DE: preset to f = 50 Hz and line length in km, only IEC inverse characteristic can be selected, directional earth (ground) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r; distance protection can be selected with quadrilateral or circle characteristic.

Region US: preset to f = 60 Hz and line length in miles, ANSI inverse characteristic only, directional earth (ground) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r, no U_0 inverse characteristic.

Region World: preset to f = 50 Hz and line length in km, directional earth (ground) fault protection: no direction decision with zero-sequence power S_r, no U_0 inverse characteristic.

Region FR: preset to f = 50 Hz and line length in km, directional earth (ground) fault protection: no U_0 inverse characteristic, no logarithmic inverse characteristic, weak infeed logic selectable between French specification and world specification.

2) For SICAM energy automation systems.

3) Optical double ring interfaces are not available with surface mounting housings.

4) Not available with position 9 = "*B*"

Selection and ordering data

Description	Order No.	Order code
7SA6 distance protection relay for all voltage levels	7SA6□□□-□□□□□-□□□□	□□□
Port C and port D		
Port C: DIGSI/modem, electrical RS232, Port D: empty	1	
Port C: DIGSI/modem, electrical RS485, Port D: empty	2	
Port C and Port D installed	9	M □□

see pages 6/34 and 6/35

Description	Order code
Port C	
DIGSI/modem, electrical RS232	1
DIGSI/modem, electrical RS485	2
Port D	
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 1.5 km For direct connection via multi-mode FO cable or communication networks [1]	A
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 3.5 km For direct connection via multi-mode FO cable	B
Two analog outputs, each 0...20 mA	K
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 25 km for direct connection via mono-mode FO cable[2]	G
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable[2]	H
Protection data interface: optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable[2]	J

1) For suitable communication converters 7XV5662 (optical to G703.1/X21/RS422 or optical to pilot wire) see "Accessories".

2) For surface -mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.

Selection and ordering data

Description	Order No.
7SA6 distance protection relay for all voltage levels	*7SA6□□□-□□□□□-□□□□*

Functions 1

Trip mode	Thermal overload protection (ANSI 49)	BCD-coded output for fault location	
3-pole			*0*
3-pole		■	*1*
3-pole	■		*2*
3-pole	■	■	*3*
1/3-pole			*4*
1/3-pole		■	*5*
1/3-pole	■		*6*
1/3-pole	■	■	*7*

Functions 2

Distance protection pickup (ANSI 21, 21N)	Power swing detection (ANSI 68, 68T)	Parallel line compensation	
I>			*A*
V< / *I*>			*B*
Quadrilateral (*Z*<)			*C*
Quadrilateral (*Z*<), *V*< / *I*> / φ			*D*
Quadrilateral (*Z*<)	■		*F*
Quadrilateral (*Z*<), *V*< / *I*> / φ	■		*G*
V< / *I*>		■ 1)	*J*
Quadrilateral (*Z*<)		■ 1)	*K*
Quadrilateral (*Z*<), *V*< / *I*> / φ		■ 1)	*L*
Quadrilateral (*Z*<)	■	■ 1)	*N*
Quadrilateral (*Z*<), *V*< / *I*> / φ	■	■ 1)	*P*

Functions 3

Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	Breaker failure protection (ANSI 50BF)	Over/undervoltage protection *V*>, *V*< (ANSI 27, 59) Over/underfrequency protection (ANSI 81)	
				A
			■	*B*
		■		*C*
		■	■	*D*
	■			*E*
	■		■	*F*
	■	■		*G*
	■	■	■	*H*
■				*J*
■			■	*K*
■		■		*L*
■		■	■	*M*
■	■			*N*
■	■		■	*P*
■	■	■		*Q*
■	■	■	■	*R*

Functions 4

Directional earth-fault protection, earthed networks (ANSI 50N, 51N, 67N)	Earth-fault detection compensated/ isolated networks	Measured values extended Min, max, mean	
			0
		■	*1*
	■ 2)		*2*
	■ 2)	■	*3*
■			*4*
■		■	*5*
■	■ 2)		*6*
■	■ 2)	■	*7*

1) Only with position 7 of Order No. = *1* or *5*.

2) Only with position 7 of Order No. = *2* or *6*.

Selection and ordering data

Description	Order No.
7SA6 distance protection relay for all voltage levels	*7SA6□□□-□□□□□-□□□□*

Preferential types

Functions 1

Trip mode, 3-pole	Trip mode 1 or 3-pole	Pickup I>	Pickup V</I>	Z< (quadrilateral) V</I>/φ	Power swing detection	Parallel line compensation	Auto-reclosure	Synchro-check	Breaker failure protection	Voltage protection Frequency protection	Earth-fault protection directional for earthed networks	Earth-fault directional for compensated isolated networks	Overload protection	Measured values, extended, min. max. mean	Order No.
Basic version															
■		■								■					*1 A B 0*
														■	*1 A B 1*
Medium voltage, cables															
■		■	■						■	■	■	■ 1)	■		*3 B D 6*
■		■	■						■	■	■	■ 1)	■	■	*3 B D 7*
Medium voltage, overhead lines															
■		■	■				■		■	■	■	■ 1)	■		*3 B M 6*
■		■	■				■		■	■	■	■ 1)	■	■	*3 B M 7*
High voltage, cables															
■		■	■	■	■			■	■	■	■		■		*3 G H 4*
■		■	■	■	■			■	■	■	■		■	■	*3 G H 5*
High voltage, overhead lines															
■	■	■	■	■	■	■ 2)	■	■	■	■	■		■		*7 P R 4*
■	■	■	■	■	■	■ 2)	■	■	■	■	■		■	■	*7 P R 5*

1) Only with position 7 of Order No. = *2* or *6*.
2) Only with position 7 of Order No. = *1* or *5*.

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper) Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	*7XS5460-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	*3RV1611-1AG14*
Manual for 7SA6 English, V4.61 and higher	*C53000-G1176-C156-5*

6

Accessories

Description	Order No.
Opto-electric communication converters	
Optical to X21/RS422 or G703.1	7XV5662-0AA00
Optical to pilot wires	7XV5662-0AC00
Additional interface modules	
Protection data interface FO 5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	C53207-A351-D651-1
Protection data interface FO 6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
Protection data interface FO 17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	C53207-A322-B115-3
Protection data interface FO 18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A322-B116-3
Protection data interface FO 19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A322-B117-3
Optical repeaters	
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	7XV5461-0BG00
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00

Fig. 6/35 Mounting rail for 19" rack

Fig. 6/36
2-pin connector

Fig. 6/37
3-pin connector

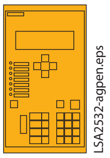
Fig. 6/38
Short-circuit link for current contacts

Fig. 6/39
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	C73334-A1-C35-1	1	Siemens	6/36
	3-pin	C73334-A1-C36-1	1	Siemens	6/37
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP [1]	
		0-827396-1	1	AMP [1]	
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP [1]	
		0-827397-1	1	AMP [1]	
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP [1]	
		0-163084-2	1	AMP [1]	
Crimping tool	For Type III+	0-539635-1	1	AMP [1]	
	and matching female	0-539668-2		AMP [1]	
	for CI2	0-734372-1	1	AMP [1]	
	and matching female	1-734387-1		AMP [1]	
19"-mounting rail		C73165-A63-D200-1	1	Siemens	6/35
Short-circuit links	For current terminals	C73334-A1-C33-1	1	Siemens	6/38
	For other terminals	C73334-A1-C34-1	1	Siemens	6/39
Safety cover for terminals	large	C73334-A1-C31-1	1	Siemens	6/4
	small	C73334-A1-C32-1	1	Siemens	6/4

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram



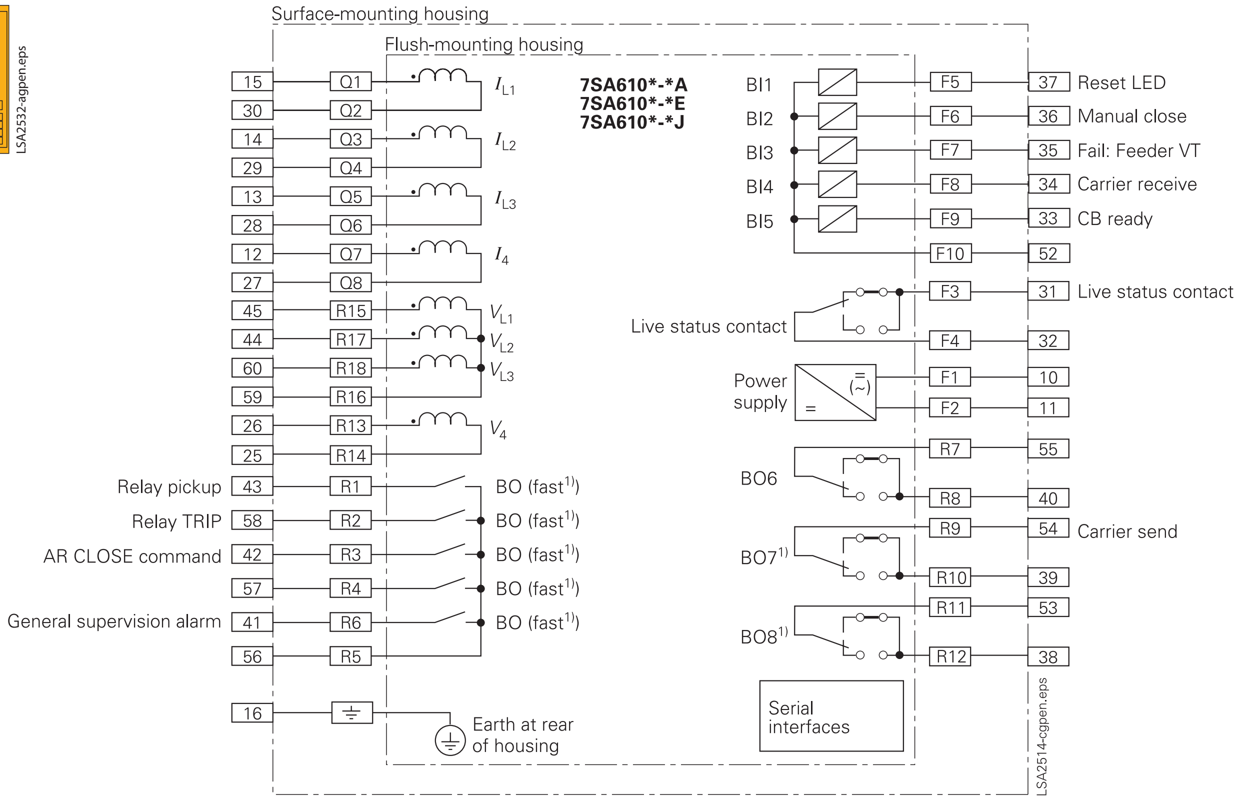


Fig. 6/40
Connection diagram

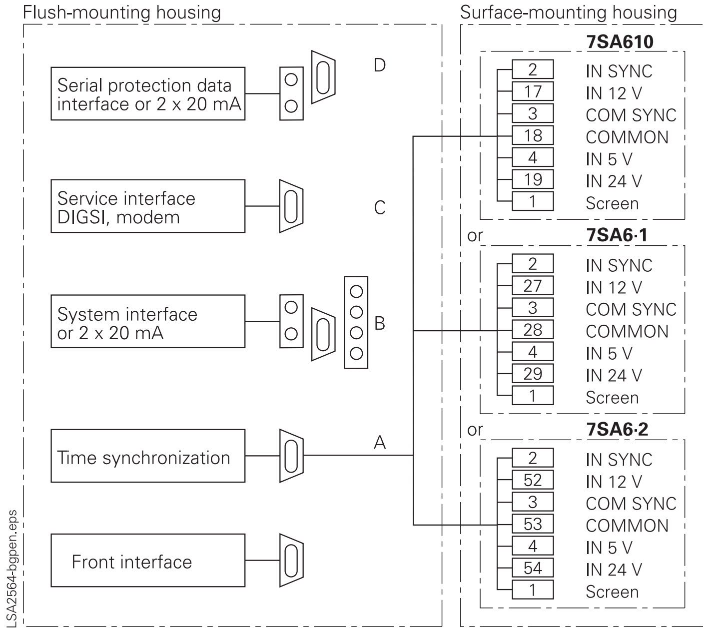
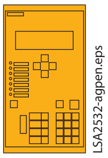


Fig. 6/41
Serial interfaces

1) Starting from unit version ..../EE.

Connection diagram



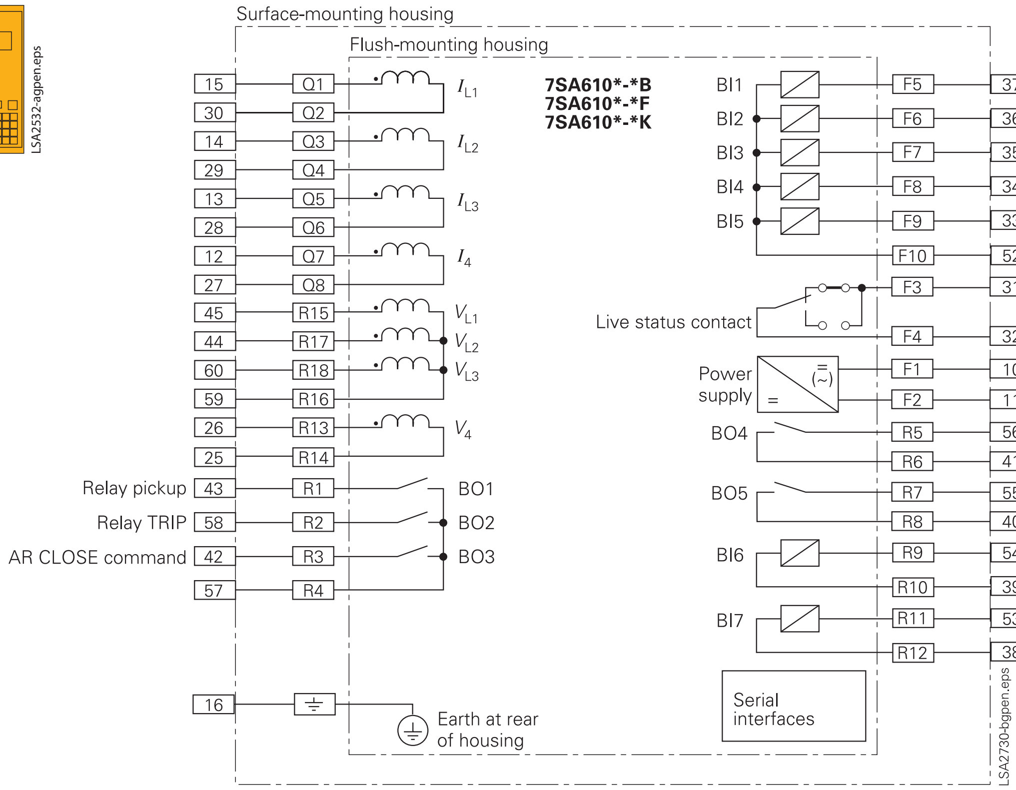
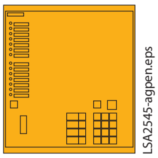


Fig. 6/42
Connection diagram

Note: For serial interfaces see Fig. 6/41.

Connection diagram



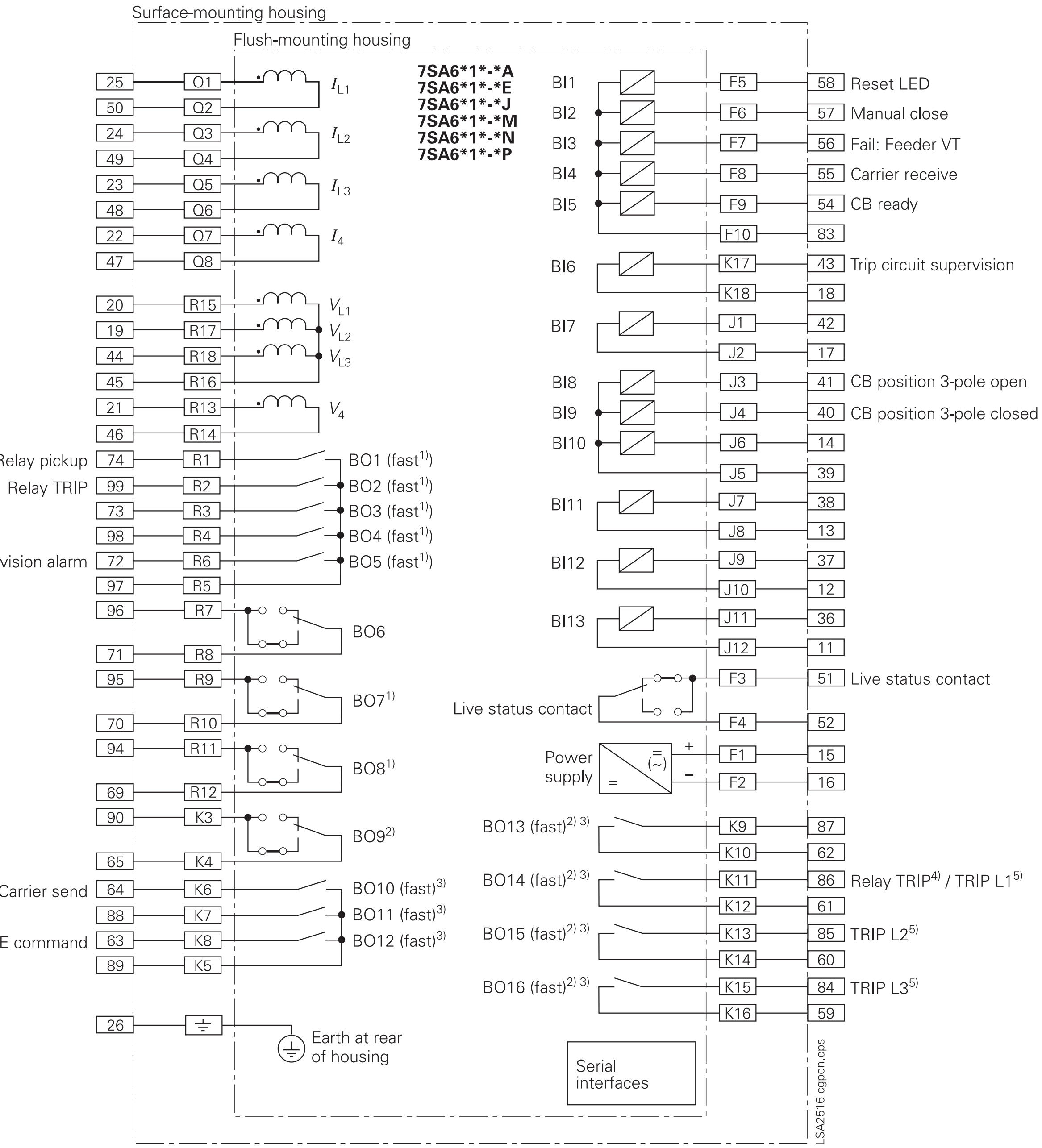


Fig. 6/43
Connection diagram

1) Starting from unit version .../EE.

2) High-speed trip outputs in versions 7SA6*1*-*M, 7SA*1*-*N, 7SA*1*-*P.
Time advantage of high-speed relays over fast relays: approx. 5 ms

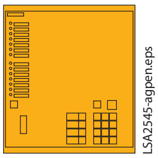
3) Time advantage with fast relay approx. 3 ms.

4) Version with 3-pole tripping.

5) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/41.

Connection diagram



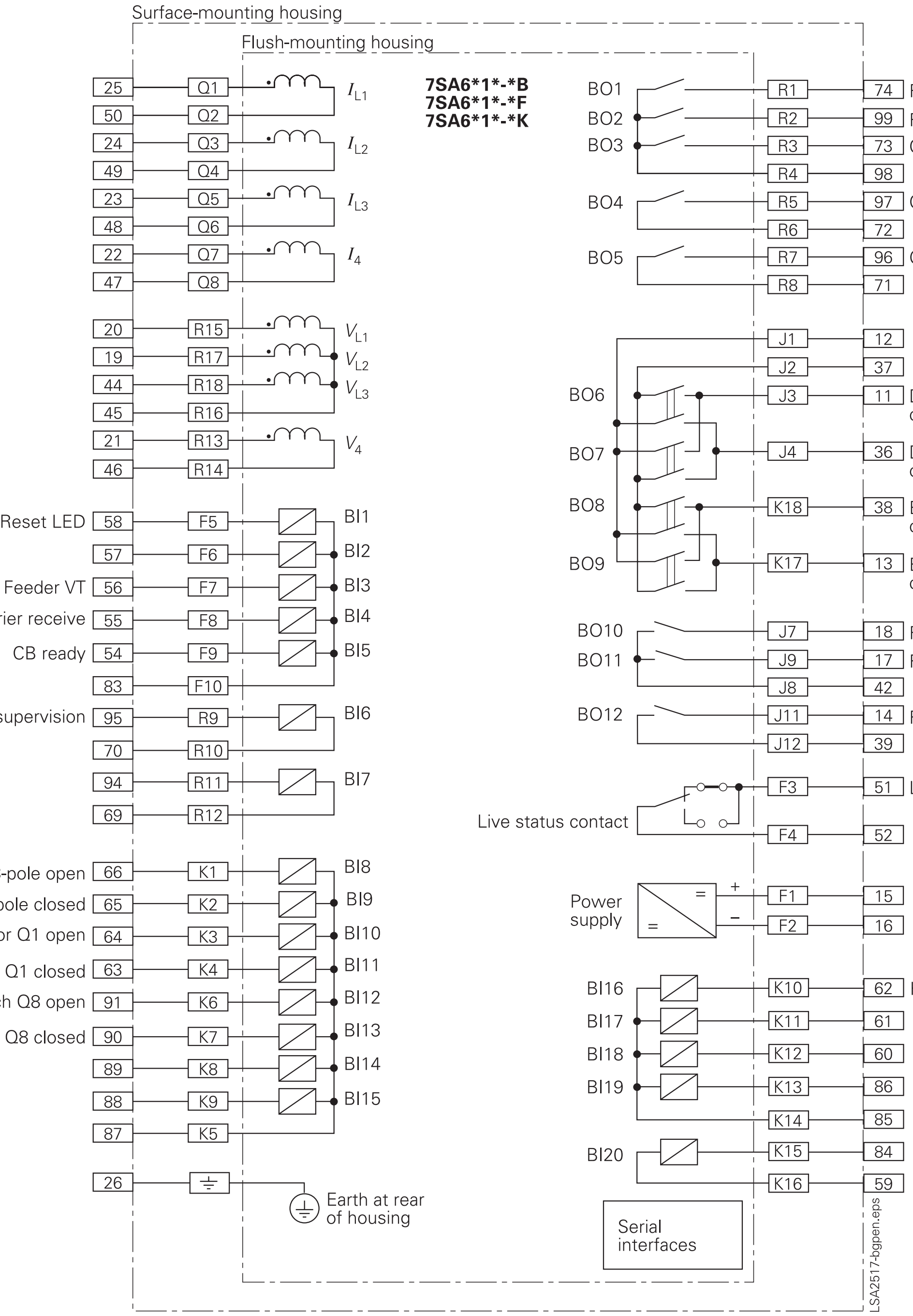
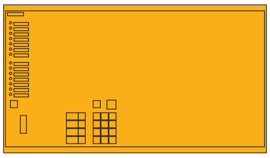
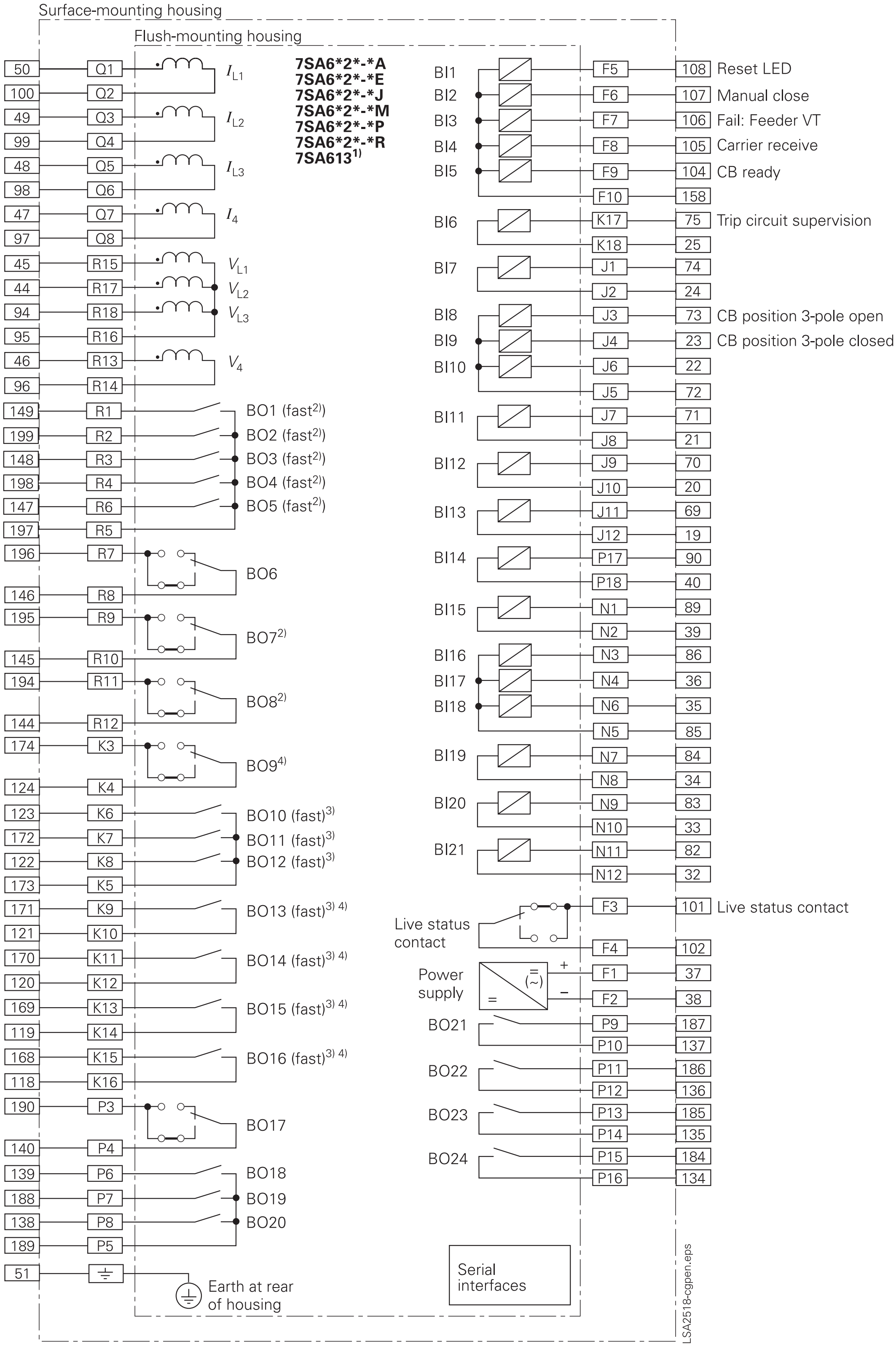


Fig. 6/44
Connection diagram

1) Version with 3-pole tripping.
2) Each pair of contacts is mechanically interlocked to prevent simultaneous closure.
3) Version with 1/3-pole tripping.
Note: For serial interfaces see Fig. 6/41.

Connection diagram


LSA2546-agpen.eps



1) 7SA613 is only available in a 2/3 x 19" flush-mounting housing.

2) Starting from unit version .../EE

3) Time advantage with fast relay approx. 3 ms.

4) High-speed trip outputs in versions 7SA6*2*-*M, 7SA6*2*-*P, 7SA6*2*-*R. Time advantage of high-speed relays over fast relays: approx. 5 ms

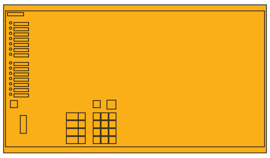
5) Version with 3-pole tripping.

6) Version with 1/3-pole tripping.

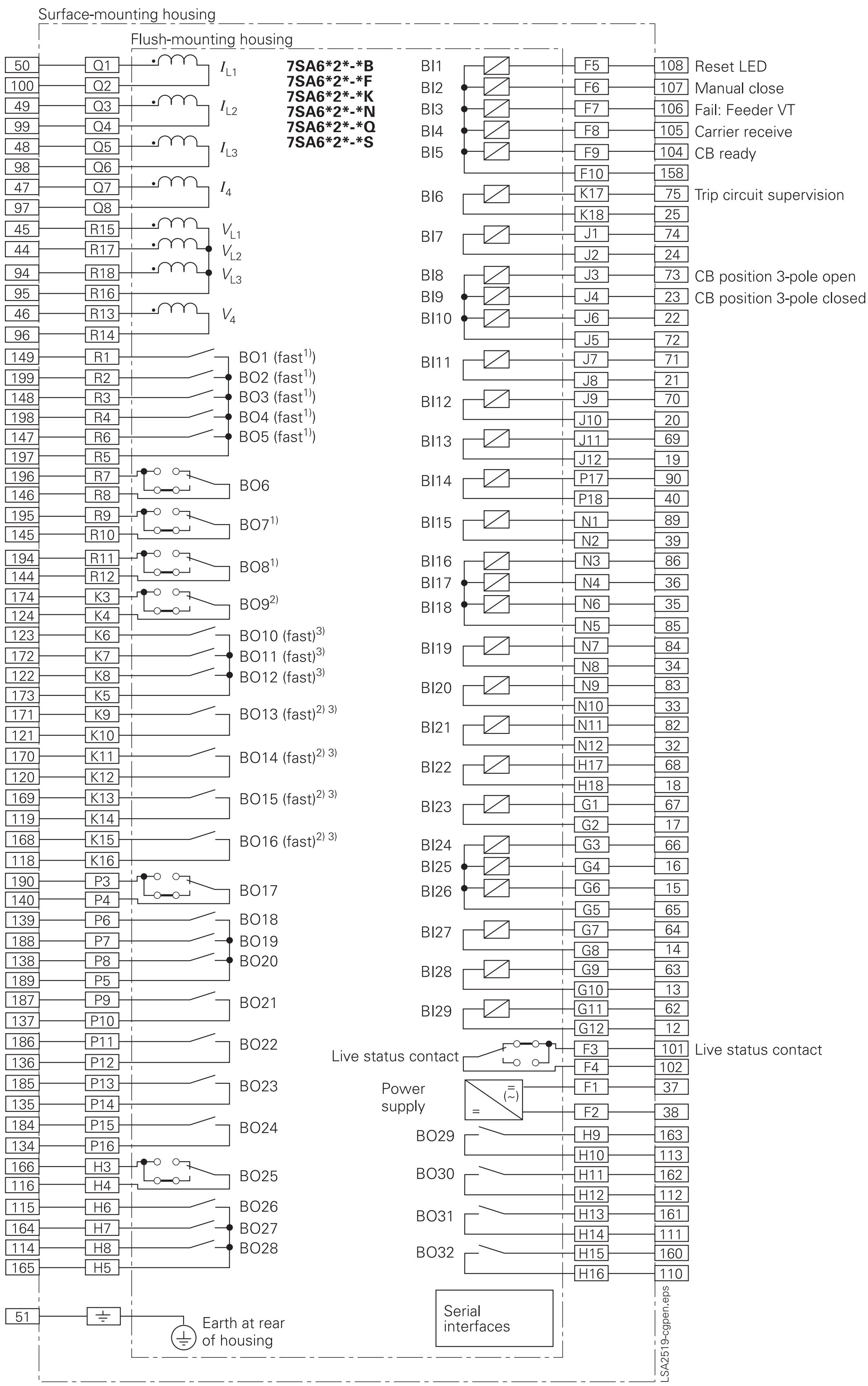
Note: For serial interfaces see Fig. 6/41.

Fig. 6/45
Connection diagram

Connection diagram



LSA2546-agpen.eps



1) Starting from unit version .../EE.

2) High-speed trip outputs in versions 7SA6*2*-*N, 7SA6*2*-*Q, 7SA6*2*-*S.

3) Time advantage with fast relay approx. 3 ms.

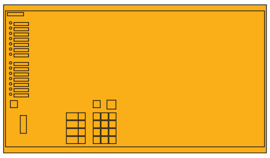
4) Version with 3-pole tripping.

5) Version with 1/3-pole tripping. Time advantage of high-speed relays over fast relays: approx. 5 ms.

Note: For serial interfaces see Fig. 6/41.

Fig. 6/46 Connection diagram

Connection diagram



LSA2546-agpen.eps

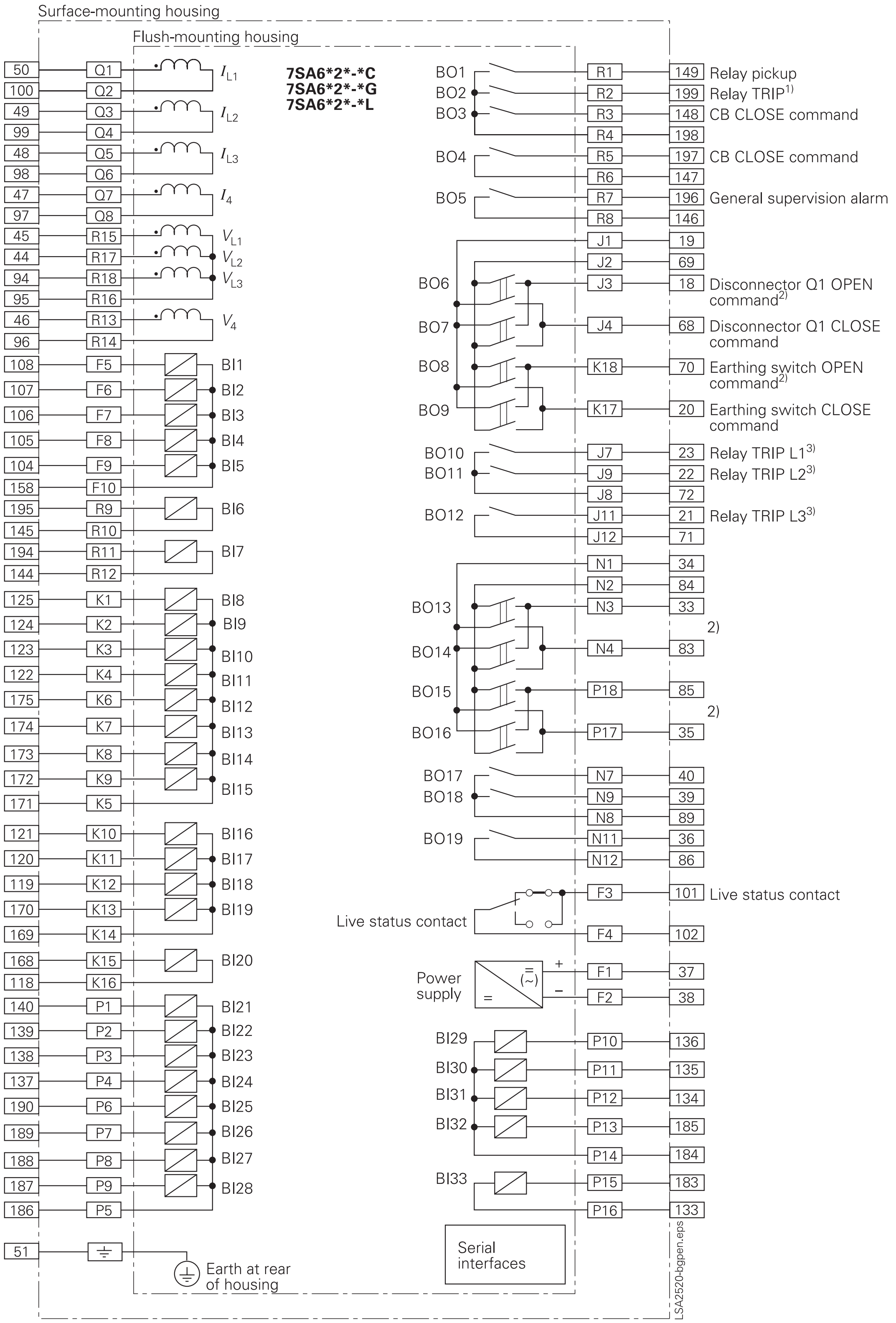


Fig. 6/47 Connection diagram

1) Version with 3-pole tripping.

2) Each pair of contacts is mechanically interlocked to prevent simultaneous closure.

3) Version with 1/3-pole tripping.

Note: For serial interfaces see Fig. 6/41.

SIPROTEC 4 7SA522
Distance Protection Relay for Transmission Lines

LSP2309-afpen.tif

Fig. 6/48 SIPROTEC 4
7SA522 distance protection relay

Description

The SIPROTEC 4 7SA522 relay provides full-scheme distance protection and incorporates all functions usually required for the protection of a power line. The relay is designed to provide fast and selective fault clearance on transmission and subtransmission cables and overhead lines with or without series capacitor compensation. The power system star point can be solid or resistance grounded (earthed), resonant-earthed via Peterson coil or isolated. The 7SA522 is suitable for single-pole and three-pole tripping applications with and without tele (pilot) protection schemes.

The 7SA522 incorporates several protective functions usually required for transmission line protection.

– High-speed tripping time

– Suitable for cables and overhead lines with or without series capacitor compensation

– Self-setting power swing detection for frequencies up to 7 Hz

– Digital relay-to-relay communication for two and three terminal topologies

– Adaptive auto-reclosure (ADT)

Function overview

Protection functions

- Non-switched distance protection with 6 measuring systems (21/21N)
- High resistance ground (earth)-fault protection for single- and three-pole tripping (50N/51N/67N)
- Tele (pilot) protection (85)
- Fault locator (FL)
- Power swing detection/tripping (68/68T)
- Phase-overcurrent protection (50/51/67)
- STUB bus overcurrent protection (50 STUB)
- Switch-onto-fault protection (50HS)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79)
- Synchro-check (25)
- Breaker failure protection (50BF)

Control functions

- Commands f. ctrl of CB and isolators

Monitoring functions

- Trip circuit supervision (74TC)
- Self-supervision of the relay
- Measured-value supervision
- Event logging/fault logging
- Oscillographic fault recording
- Switching statistics

Front design

- User-friendly local operation with numeric keys
- LEDs for local alarm
- PC front port for convenient relay setting
- Function keys

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
  – IEC 61850 Ethernet
  – IEC 60870-5-103 protocol
  – PROFIBUS-FMS/-DP
  – DNP 3.0
- 2 serial protection data interfaces for tele (pilot) protection
- Rear-side service/modem interface
- Time synchronization via IRIG B or DCF77 or system interface

Hardware

- Binary inputs: 8/16/24
- Output relays: 16/24/32
- High-speed trip outputs: 5 (optional)

Application

The 7SA522 relay provides full-scheme distance protection and incorporates all functions usually required for the protection of a power line. The relay is designed to provide fast and selective fault clearance on transmission and subtransmission cables and overhead lines with or without series capacitor compensation. This contributes towards improved stability and availability of your electrical power transmission system. The power system star point can be solid or impedance grounded (earthed), resonant-earthed via Peterson coil or isolated. The 7SA522 is suitable for single and three-pole tripping applications with and without tele (pilot) protection schemes.

The effect of apparent impedances in unfaulted fault loops is eliminated by a sophisticated and improved method which uses pattern recognition with symmetrical components and load compensation. The correct phase selection is essential for selective tripping and reliable fault location.

During network power swings, an improved power swing blocking feature prevents the distance protection from unwanted tripping and optionally provides controlled tripping in the event of loss of synchronism (out of step). This function guarantees power transmission even under critical network operating conditions.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control and interlocking change, it is possible in the majority of the cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.

The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

Features

- High speed tripping time
- Suitable for cables and overhead lines with or without series capacitor compensation
- Self setting power swing detection fo frequencies up to 7 Hz
- Digital relay-to-relay communication for two and three terminal topologies
- Adaptive auto-reclosure (ADT)

ANSI	Protection function
21/21N	Distance protection
FL	Fault locator
50N/51N 67N	Directional earth(ground)-fault protection
50/51/67	Backup overcurrent protection
50 STUB	STUB-bus overcurrent stage
68/68T	Power swing detection/tripping
85/21	Teleprotection for distance protection
27WI	Weak-infeed protection
85/67N	Teleprotection for earth(ground)-fault protection
50HS	Switch-onto-fault protection
50BF	Breaker failure protection
59/27	Overvoltage/undervoltage protection
81O/U	Over/underfrequency protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)

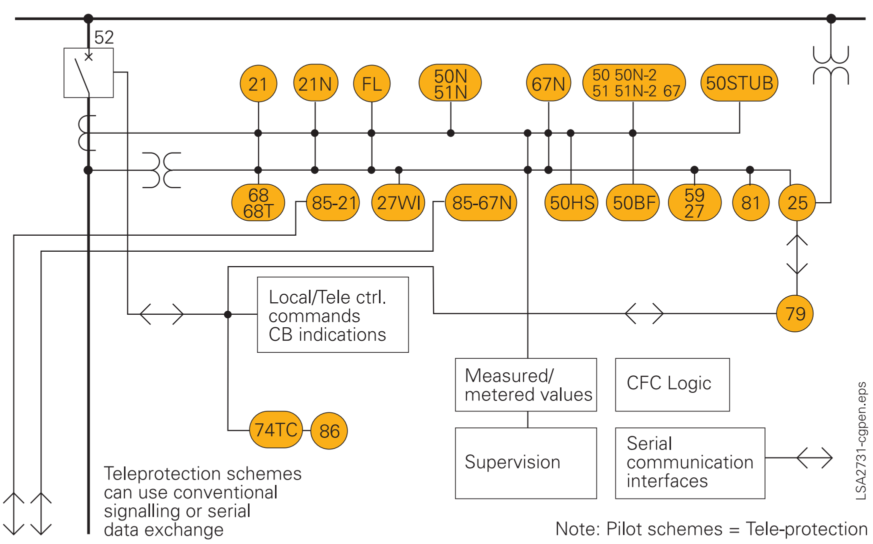


Fig. 6/49
Single-line diagram

Construction

Connection techniques and housing with many advantages

1/2 and 1/1-rack sizes

These are the available housing widths of the SIPROTEC 4 7SA522 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 245 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option.

It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

Fig. 6/50
Housing widths 1/2 x 19" and 1/1 x 19"

Fig. 6/51
Rear view with screw-type terminals and serial interfaces

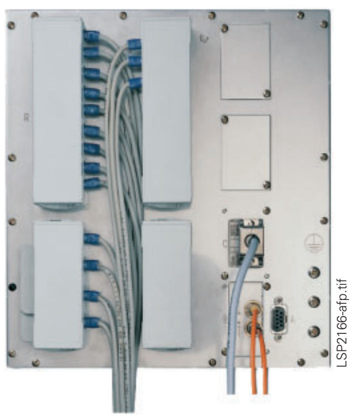


Fig. 6/52
Rear view with terminal covers and wiring

Protection functions

Distance protection (ANSI 21, 21N)

The main function of the 7SA522 is a full-scheme distance protection. By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of faults. The shortest tripping time is less than one cycle. Single-pole and three-pole tripping is possible. The distance protection is suitable for cables and overhead lines with or without series capacitor compensation.

Mho and quadrilateral characteristics

The 7SA522 relay provides quadrilateral as well as mho zone characteristics. Both characteristics can be used separately for phase and ground (earth) faults. Resistance ground (earth) faults can, for instance, be covered with the quadrilateral characteristic and phase faults with the mho characteristic.

Load zone

In order to guarantee a reliable discrimination between load operation and short-circuit - especially on long high loaded lines - the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity

The 7SA522 distance protection incorporates a well-proven, highly sophisticated phase selection algorithm. The pickup of unfaulted loops is reliably eliminated to prevent the adverse influence of currents and voltages in the fault-free loops. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range.

Parallel line compensation

The influence of wrong distance measurement due to parallel lines can be compensated by feeding the neutral current of the parallel line to the relay. Parallel line compensation can be used for distance protection as well as for the fault locator.

6 distance zones

Five independent distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partly separate for single-phase or multi-phase faults. Ground (earth) faults are detected by monitoring the neutral current $3I_0$ and the zero-sequence voltage $3V_0$.

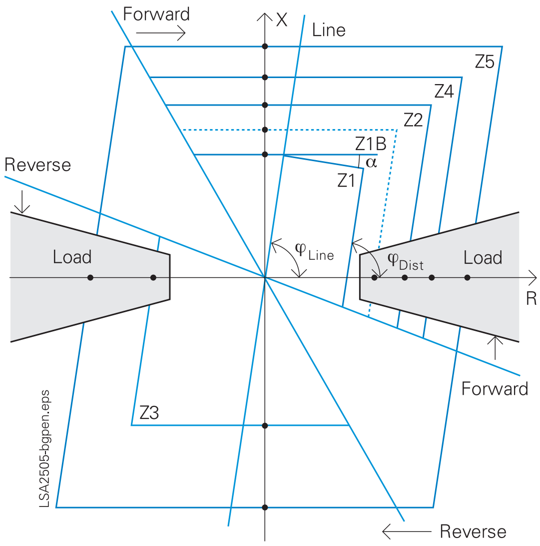


Fig. 6/53
Distance protection: quadrilateral characteristic

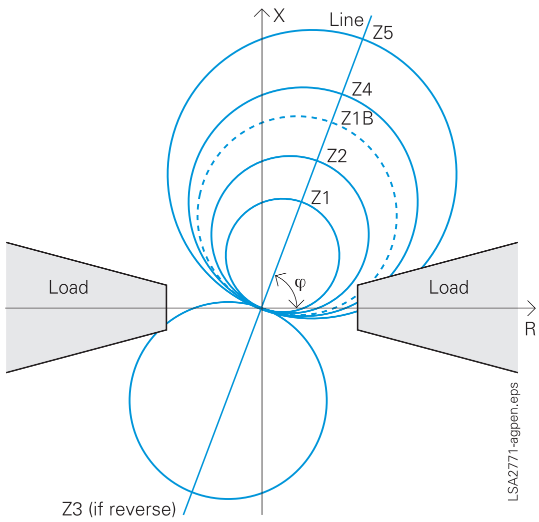


Fig. 6/54
Distance protection: mho characteristic

The quadrilateral tripping characteristic permits separate setting of the reactance X and the resistance R. The resistance section R can be set separately for faults with and without earth involvement. This characteristic has therefore an optimal performance in case of faults with fault resistance. The distance zones can be set forward, reverse or non-directional. Sound phase polarization and voltage memory provides a dynamically unlimited directional sensitivity.

Mho

The mho tripping characteristic provides sound phase respectively memory polarization for all distance zones. The example in this figure shows the characteristic for a forward fault where the mho circle expands to the source impedance but never more than the selected impedance reach. This mho circle expansion guarantees safe and selective operation for all types of faults, even for close-in faults.

Protection functions

Elimination of interference signals

Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.

The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and, in this case, the EMERGENCY definite-time overcurrent protection can be activated.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The result is displayed in ohms, miles, kilometers or in percent of the line length. Parallel line and load current compensation is also available.

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SA522 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

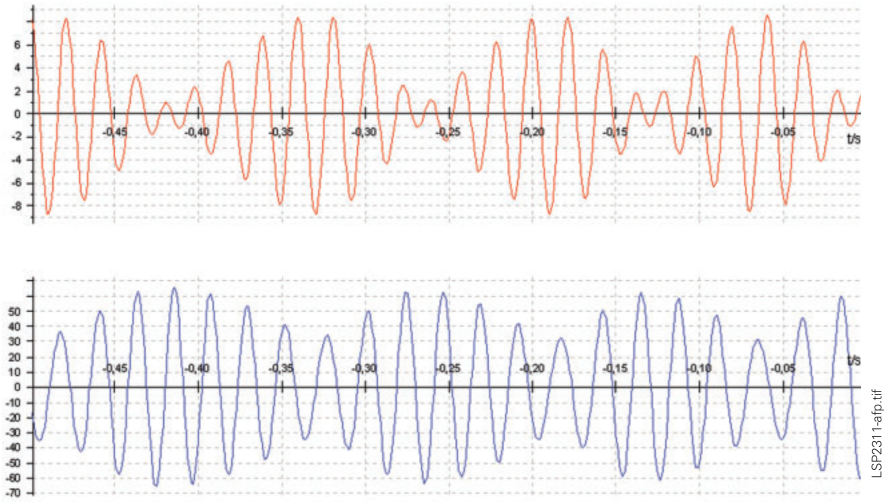


Fig. 6/55

Power swing current and voltage wave forms

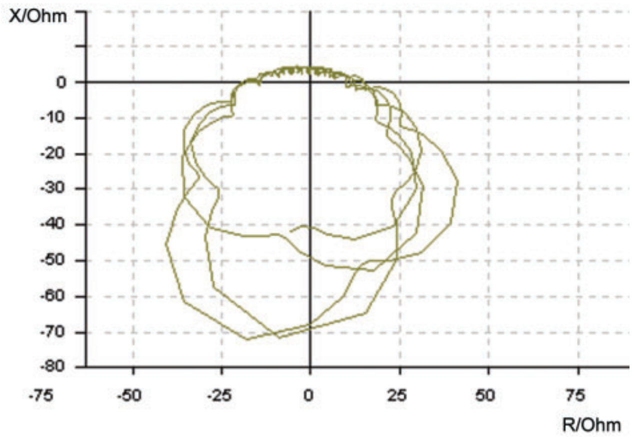


Fig. 6/56

Power swing circle diagram

– PUTT, permissive underreaching zone transfer trip

– POTT, permissive overreaching zone transfer trip

– UNBLOCKING

– BLOCKING

– DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function)

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

Common transmission channels are power-line carrier, microwave radio and fiber-optic links. A serial protection data interface for direct connection to a digital communication network or fiber-optic link is available as well.

7SA522 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if two single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines).

Phase-selective transmission is also possible with multi-end applications, if some user-specific linkages are implemented by way of the integrated CFC logic. During disturbances in the transmission receiver or on the transmission circuit, the teleprotection function can be blocked by a binary input signal without losing the zone selectivity. The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function. A transient blocking function (Current reversal guard) is provided in order to suppress interference signals during tripping of parallel lines.

Protection functions

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SA522 relay is equipped with phase-selective intertripping signal inputs and outputs.

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided.
If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line. It is also possible to initiate tripping at the weak-infeed end. A phase-selective 1-pole or 3-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-earth voltage drops correspondingly. As an option, the weak infeed logic can be equipped according to a French specification.

Directional ground(earth)-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In grounded (earthed) networks, it may happen that the distance protection sensitivity is not sufficient to detect high-resistance ground (earth) faults. The 7SA522 protection relay therefore has protection functions for faults of this nature.

The ground (earth)-fault overcurrent protection can be used with 3 definite-time stages and one inverse-time stage (IDMT). A 4th definite-time stage can be applied instead of the one inverse-time stage.

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”). An additional logarithmic inverse-time characteristic is also available.

The direction decision can be determined by the neutral current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2. In addition or as an alternative to the directional determination with zero-sequence voltage, the star-point current of an grounded (earthed) power transformer may also be used for polarization. Dual polarization applications can therefore be fulfilled.

Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or for both directions (non-directional).

As an option, the 7SA522 relay can be provided with a sensitive neutral (residual) current transformer. This feature provides a measuring range for the neutral (residual) current from 5 mA to 100 A with a nominal relay current of 1 A and from 5 mA to 500 A with a nominal relay current of 5 A. Thus the ground(earth)-fault overcurrent protection can be applied with extreme sensitivity.

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for low zero-sequence fault currents which usually have a high content of 3rd and 5th harmonics. Inrush stabilization and instantaneous switch-onto-fault trip can be activated separately for each stage as well.

Different operating modes can be selected. The ground(earth)-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

Tele (pilot) protection for directional ground(earth)-fault protection (ANSI 85-67N)

The directional ground(earth)-fault overcurrent protection can be combined with one of the following teleprotection schemes:

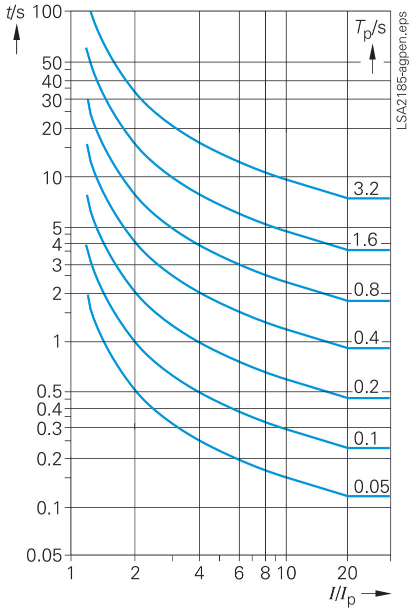
- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for ground(earth)-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N, 67)

The 7SA522 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the neutral (residual) current.



$$t = \frac{0.14}{\left(I/I_p\right)^{0.02} - 1} T_p$$

Fig. 6/57 Normal inverse

The application can be extended to a directional overcurrent protection (ANSI 67) by taking into account the decision of the available direction detection elements.

Two operating modes are selectable. The function can run in parallel to the distance protection or only during failure of the voltage in the VT secondary circuit (emergency operation).

The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see “Technical data”).

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated from a binary input signalling the open line isolator (disconnector) is open.
Settings are available for phase and ground(earth)-faults.

Protection functions

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast 3-pole tripping.

With lower fault currents, instantaneous tripping after switch-onto-fault is also possible with the overreach distance zone Z1B or just with pickup in any zone.

The switch-onto-fault initiation can be detected via the binary input "manual close" or automatically via measurement.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or that are only lightly loaded. The 7SA522 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4th voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding).
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SA522 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Breaker failure protection (ANSI 50BF)

The 7SA522 relay incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes.

If the fault current is not interrupted after a time delay has expired, a retrip command or the busbar trip command will be generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

Auto-reclosure (ANSI 79)

The 7SA522 relay is equipped with an auto-reclose function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without earth, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without earth and 3-pole auto-reclosure for other faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the integrated AR function by external protection
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed: When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole , it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g., checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Protection functions

Fuse failure monitoring and other supervision functions

The 7SA522 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit, the distance protection would respond with an unwanted trip due to this loss of voltage. This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection and switching to the backup-emergency protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Broken-conductor supervision
- Summation of currents and voltages
- Phase-sequence supervision

Directional power protection

The 7SA522 has a function for detecting the power direction by measuring the phase angle of the positive-sequence system's power. Fig. 6/58 shows an application example displaying negative active power. An indication is issued in the case when the measured angle φ (S1) of the positive-sequence system power is within the P - Q - level sector. This sector is between angles φ A and φ B.
Via CFC the output signal of the directional monitoring can be linked to the "Direct Transfer Trip (DTT)" function and thus, as reverse power protection, initiate tripping of the CB.

Fig.6/59 shows another application displaying capacitive reactive power. In the case of overvoltage being detected due to long lines under no-load conditions it is possible to select the lines where capacitive reactive power is measured.

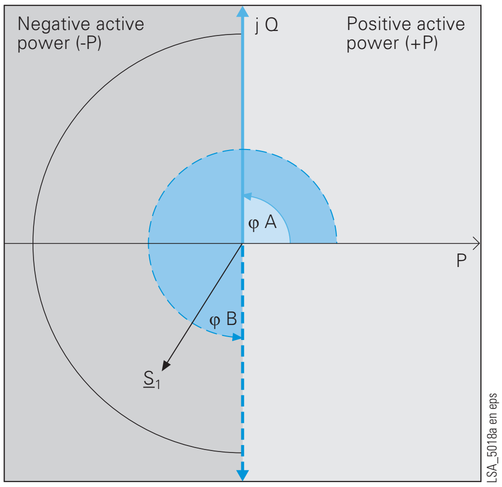


Fig. 6/58 Monitoring of active power direction

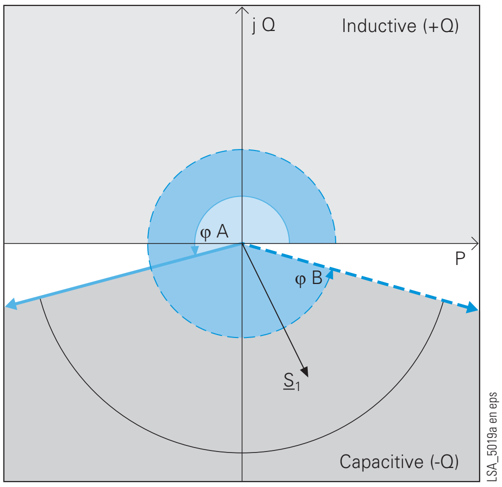


Fig. 6/59 Monitoring of reactive power

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

Under certain operating conditions, it is advisable to block CLOSE commands after a TRIP command of the relay has been issued. Only a manual “Reset” command unblocks the CLOSE command. The 7SA522 is equipped with such an interlocking logic.

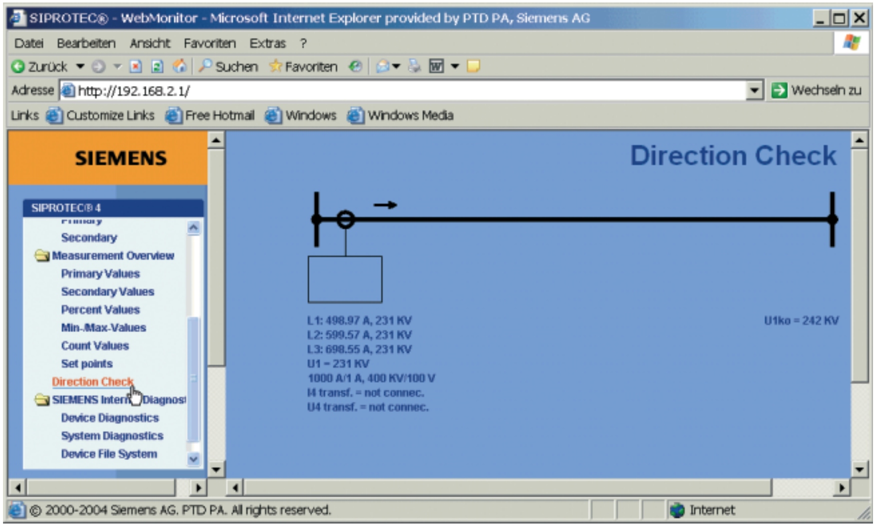
Protection functions

Commissioning and fault event analyzing

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user. The operational and fault events and the fault records are clearly arranged. For applications with serial protection data interface, all currents, voltages and phases are available via communication link at each local unit, displayed at the front of the unit with DIGSI 4 or with WEB Monitor.
A common time tagging facilitates the comparison of events and fault records.

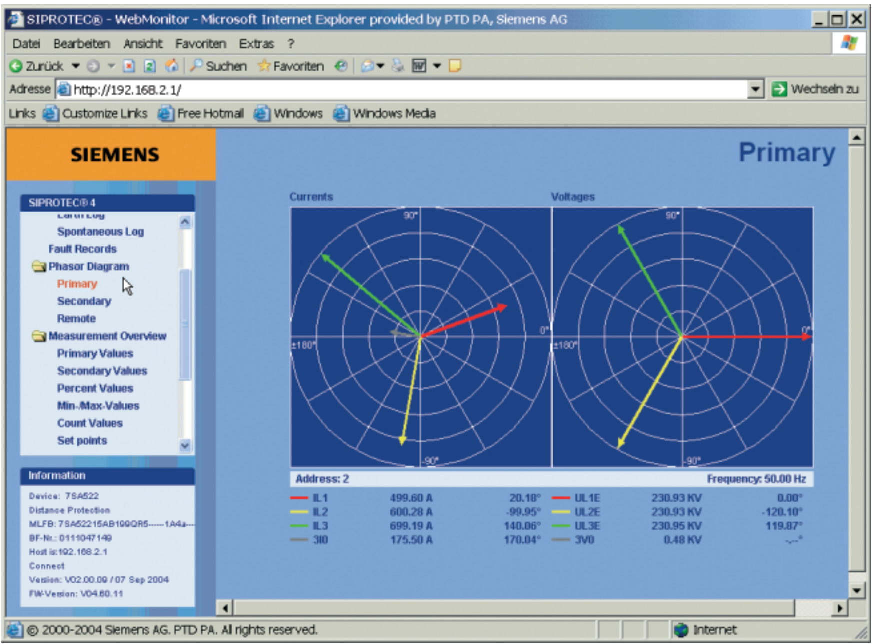
WEB Monitor - Internet technology simplifies visualization

In addition to the universal DIGSI 4 operating program, the relay contains a WEB server that can be accessed via a telecommunication link using a browser (e.g. Internet Explorer). The advantage of this solution is to operate the unit with standard software tools and at the same time make use of the Intranet/Internet infrastructure. Apart from numeric values, graphical displays in particular provide clear information and a high degree of operating reliability. Of course, it is also possible to call up detailed measured value displays and annunciation buffers. By emulation of the integrated unit operation on the PC it is also possible to adjust selected settings for commissioning purposes.



LSP2818.tif

Fig. 6/60 Web Monitor: Display of the protection direction



LSP2820.tif

Fig. 6/61 Web monitor: Supported commissioning by phasor diagram

6

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the device which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

The units offer a high degree of flexibility by supporting different standards for connection to industrial and power automation systems. By means of the communication modules, on which the protocols run, exchange and retrofit is possible. Therefore, the units will also in future allow for optimal adaptation to changing communication infrastructure such as the application of Ethernet networks (which will also be used increasingly in the power supply sector in the years to come).

Local PC interface

The serial RS232 PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

By means of the RS 485/RS 232 interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants. With the optical version, centralized operation can be implemented by means of a star coupler.

Time synchronization

The time synchronization interface is a standard feature in all units. The supported formats are IRIG-B and DCF77.

Reliable bus architecture

- RS485 bus

  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problems.

- Fiber-optic double ring circuit

  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance. It is usually impossible to communicate with a unit that has failed. Should the unit fail, there is no effect on the communication with the rest of the system.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communcation protocols (IEC 61850, IEC 60870-5-103, PROFIBUS, DNP, etc) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this Standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI. It will also be possible to retrieve operating and fault messages and fault recordings via a browser. This Web monitor will also provide a few items of unit-specific information in browser windows.

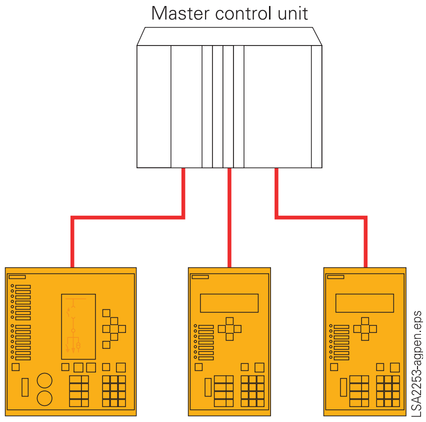
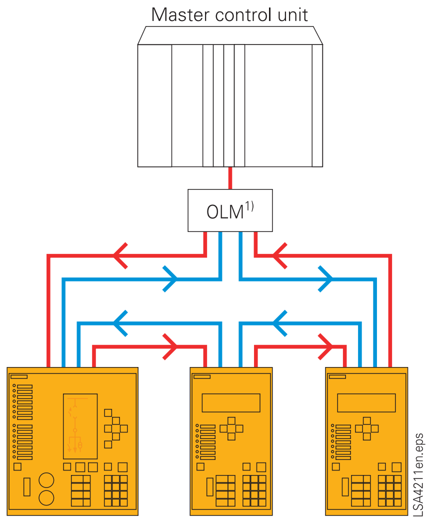


Fig. 6/62
IEC 60870-5-103 star type RS232 copper conductor connection or fiber-optic connection



1) **O**ptical **L**ink **M**odule

Fig. 6/63
Bus structure: Fiber-optic double ring circuit

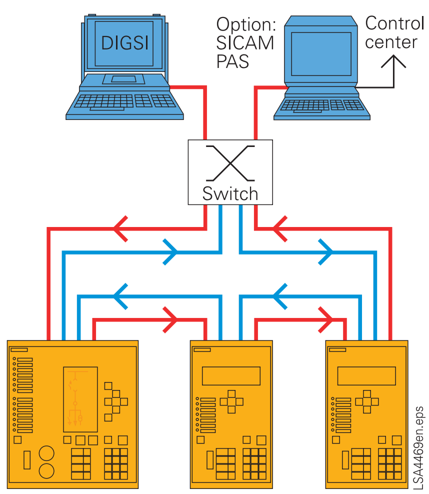


Fig. 6/64
Bus structure for station bus with Ethernet and IEC 61850

Communication

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays.
IEC 60870-5-103 is supported by a number of protection relay manufacturers and is used world-wide. Supplements for the control function are defined in the manufacturer-specific part of this standard.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized communication protocol

(EN 50170) PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world. Connection to a SIMATIC programmable controller is made on the basis of the data obtained (e.g. fault recording, fault data, measured values and control functionality) via the SICAM energy automation system.

PROFIBUS-DP

PROFIBUS-DP is an industrial communication standard and is supported by a number of PLC and protection relay manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system. Units equipped with IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or connected in star by fiber-optic link.

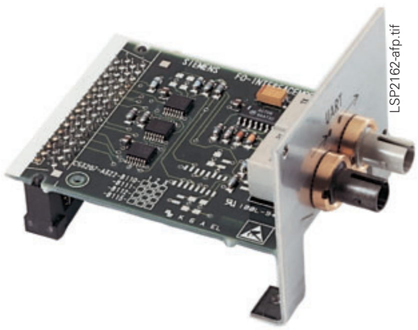


Fig. 6/65
Fiber-optic communication module

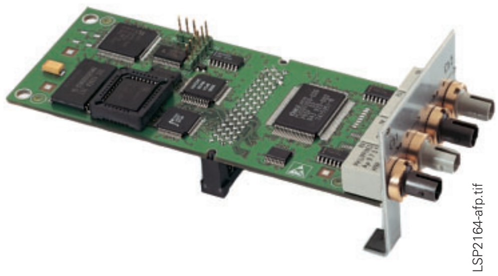


Fig. 6/66
Fiber-optic double ring communication module

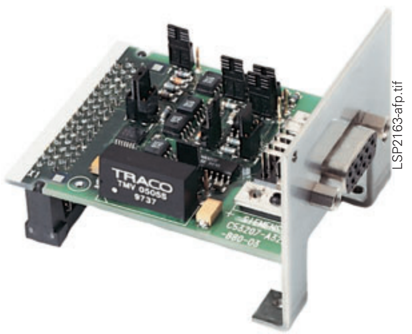


Fig. 6/67
Electrical communication module

Fig. 6/68 Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

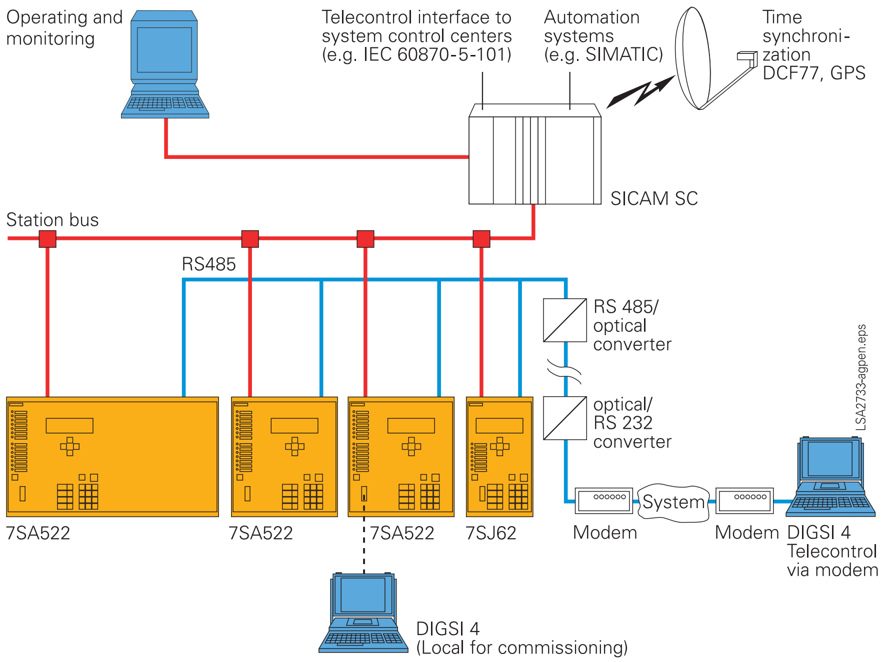


Fig. 6/69 Communication

Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 6/69).

Communication

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems. Units with an IEC 60870-5-103 interface are connected with PAS via the Ethernet station bus by means of serial/Ethernet converters. DIGSI and the Web monitor can also be used via the same station bus.

Serial protection data interface

The tele (pilot) protection schemes can be implemented using digital serial communication. The 7SA522 is capable of remote relay communication via direct links or multiplexed digital communication networks. The serial protection data interface has the following features:

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Signaling for directional ground(earth)-fault protection – directional comparison for high-resistance faults in solidly earthed systems.
- Echo-function
- Two and three-terminal line applications can be implemented without additional logic
- Interclose command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- Redundant communication path switchover is possible with the 7SA522 when 2 serial protection data interfaces are installed
- 28 remote signals for fast transfer of binary signals
- Flexible utilization of the communication channels by means of the programmable CFC logic
- Display of the operational measured values of the opposite terminal(s) with phase-angle information relative to a common reference vector
- Clock synchronization: the clock in only one of the relays must be synchronized from an external so called "Absolute Master" when using the serial protection data interface. This relay will then synchronize the clock of the other (or the two other relays in 3 terminal applications) via the protection data interface.
- 7SA522 and 7SA6 can be combined via the protection data interface.

The communication possibilities are identical to those for the line differential protection relays 7SD5 and 7SD610. The following options are available:

- FO5[1)], OMA1[2)] module: Optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km for link to communication networks via communication converters or for direct FO cable connection
- FO6[1)], OMA2[2)] module: Optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km, for direct connection via multimode FO cable
- FO17[1)]: for direct connection up to 25 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1)]: for direct connection up to 60 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1)]: for direct connection up to 100 km[3)], 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and 2 ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703.1 interface.

For operation via copper wire communication (pilot wires), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 15 km) and all three-wire protection systems using existing copper communication links.

Communication data:

- Supported network interfaces G703.1 with 64 kbit/s; X21/RS422 with 64 or 128 or 512 kbit/s
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC
- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.

Figure 6/70 shows four applications for the serial protection data interface on a two-terminal line.

1) For flush-mounting housing.
2) For surface-mounting housing.
3) For surface-mounting housing the internal fiber-optic module = OMA1 will be delivered together with an external repeater.

Communication

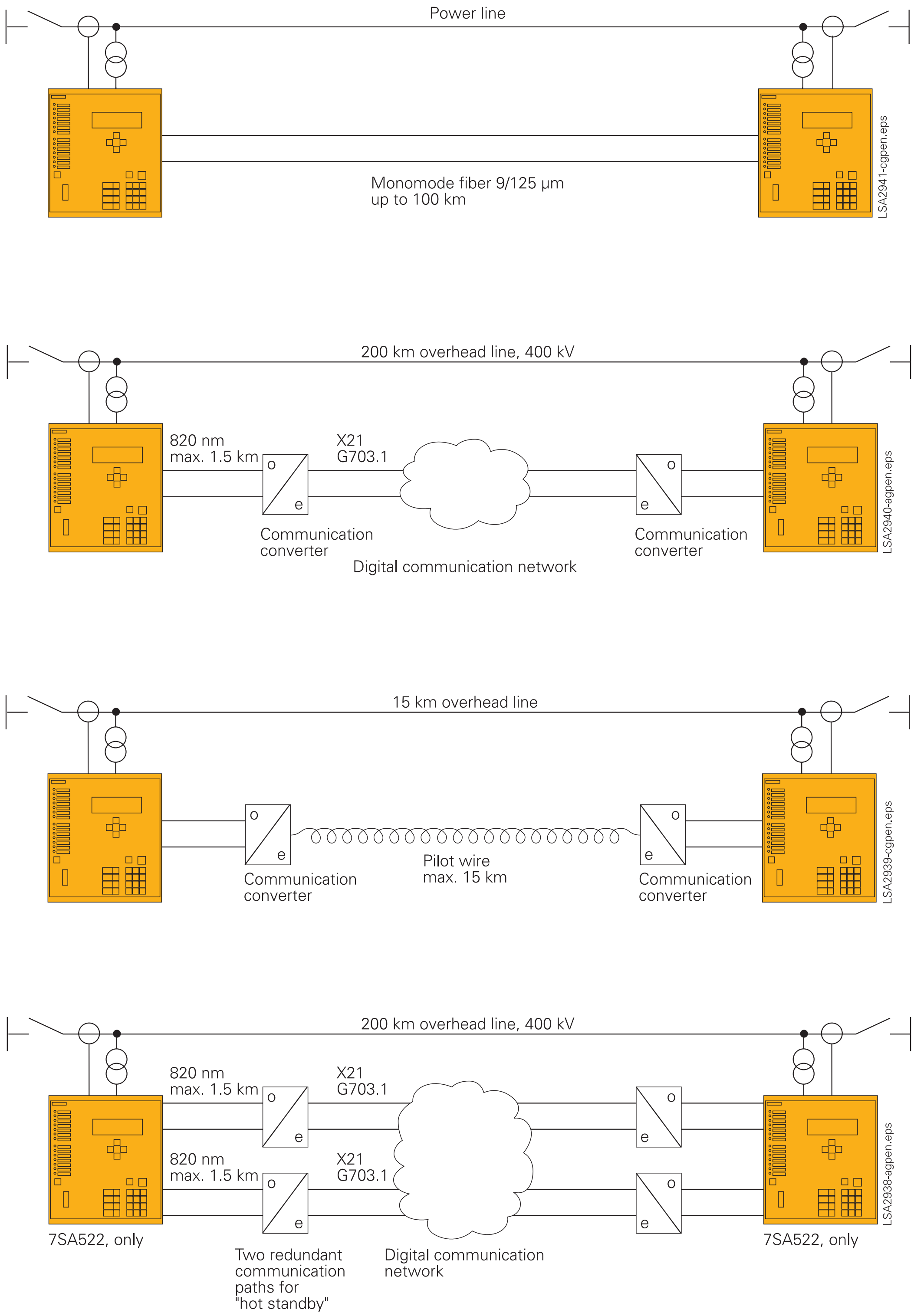


Fig. 6/70
Communication topologies for the serial protection data interface on a two-terminal line

Communication

Three-terminal lines can also be protected with a tele (pilot) protection scheme by using SIPROTEC 4 distance protection relays. The communication topology may then be a ring or a chain topology, see Fig. 6/71. In a ring topology a loss of one data connection is tolerated by the system. The topology is re-routed in a chain with less than 100 ms. To reduce communication links and to save money for communications, a chain topology may be generally applied.

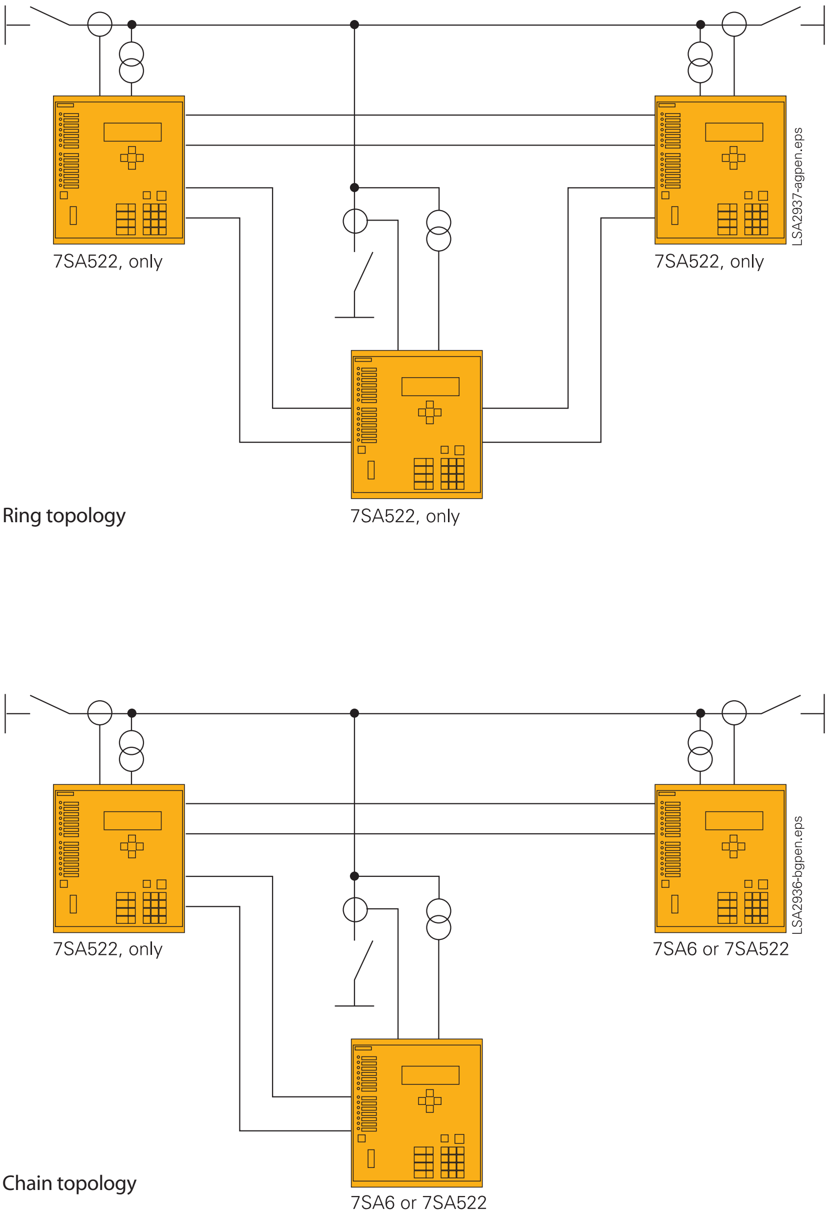


Fig. 6/71
Ring or chain communication topology

Typical connection

Connection for current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer ($=3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

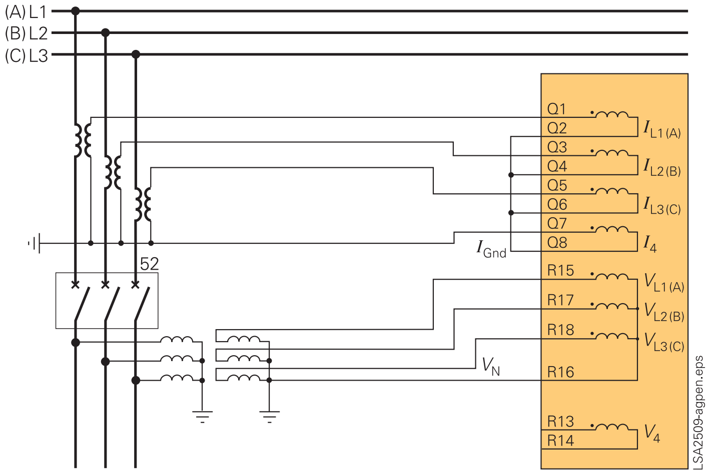


Fig. 6/72 Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core-balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 6/72, 6/76 or 6/77.

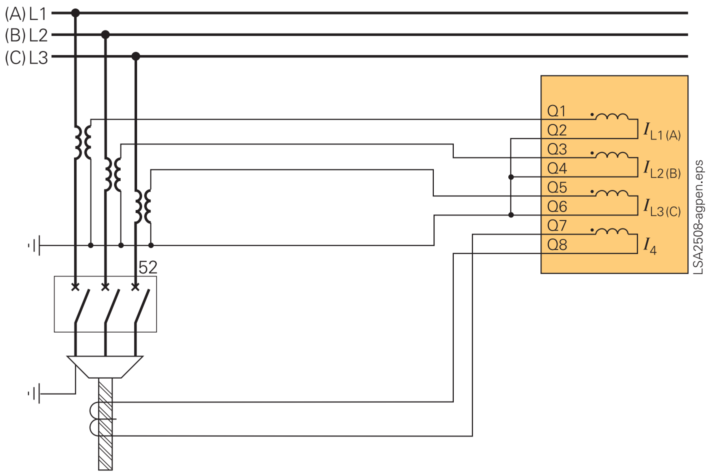


Fig. 6/73 Alternative connection of current transformers for sensitive ground(earth)-current measuring with core-balance current transformers

6

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for directional ground(earth)-fault protection. The voltage connection is effected in accordance with Fig. 6/72, 6/76 or 6/77.

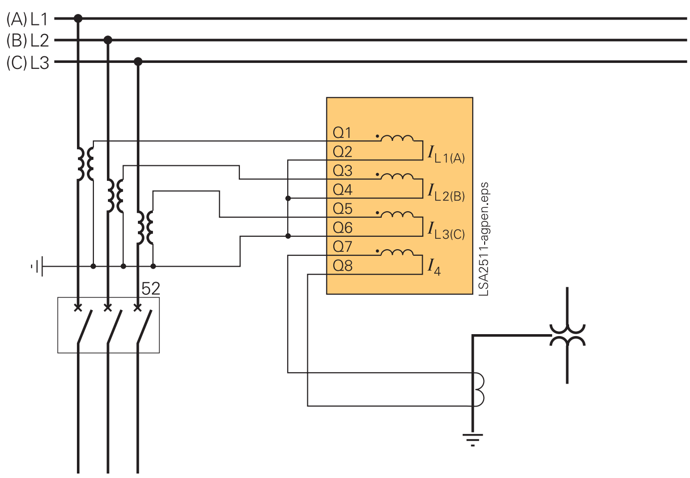


Fig. 6/74 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to the summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 6/72, 6/76 or 6/77.

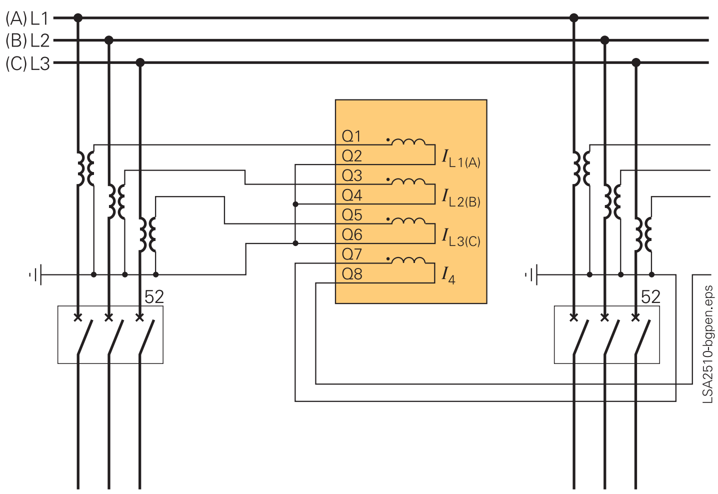


Fig. 6/75 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

Typical connection

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and ground(earth)-fault directional protection. The current connection is effected in accordance with Fig. 6/72, 6/73, 6/74 and 6/75.

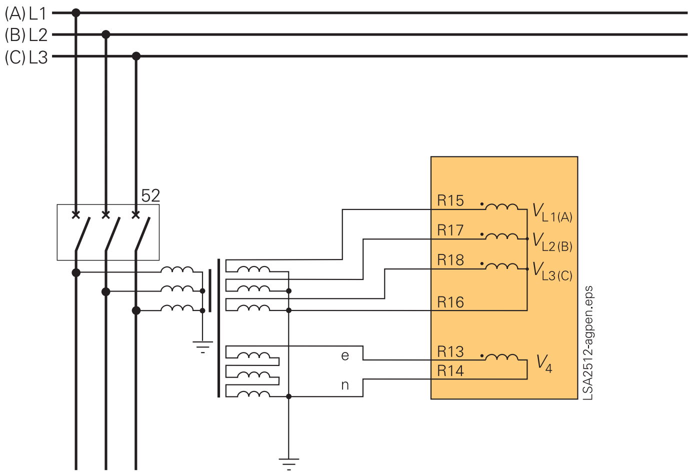


Fig. 6/76 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchro-check.

Note: Any phase-to-phase or phase-to-ground(earth) voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 6/72, 6/73, 6/74 and 6/75.

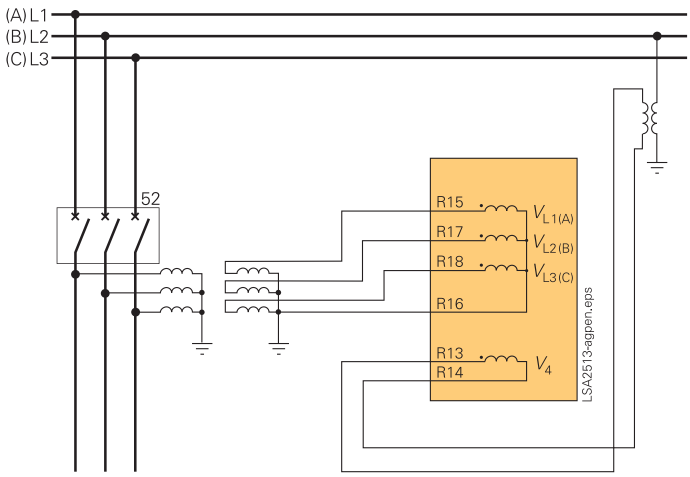


Fig. 6/77 Alternative connection of voltage transformers for measuring the busbar voltage

Technical data

General unit data

Analog input

Rated frequency	50 or 60 Hz (selectable)
Rated current I_{nom}	1 or 5 A (selectable)
Rated voltage	80 to 125 V (selectable)
Power consumption In CT circuits with I_{nom} = 1 A In CT circuits with I_{nom} = 5 A In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code) at 1 A In VT circuits	 Approx. 0.05 VA Approx. 0.30 VA Approx. 0.05 VA Approx. 0.10 VA
Thermal overload capacity In CT circuits In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code) In VT circuits	 500 A for 1 s 150 A for 10 s 20 A continuous 300 A for 1 s 100 A for 10 s 15 A continuous 230 V continuous per phase
Dynamic overload capacity In CT circuits In the CT circuit for high sensitive ground(earth)-fault protection (refer to ordering code)	 1250 A (one half cycle) 750 A (one half cycle)

Auxiliary voltage

Rated auxiliary voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V AC with 50/60 Hz
Permissible tolerance of the rated auxiliary voltage	-20 % to +20 %
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption During normal operation During pickup with all inputs and outputs activated	 Approx. 8 W Approx. 18 W
Bridging time during auxiliary voltage failure V_{aux} = 48 V and V_{aux} ≥ 110 V	 ≥ 50 ms

Binary inputs

Quantity Functions are freely assignable	8 or 16 or 24 (refer to ordering code)
Pickup/Reset voltage thresholds Ranges are settable by means of jumpers for each binary input	19 V DC/10 V DC or 88 V DC/44 V DC or 176 V DC/88 V DC, bipolar (3 nominal ranges 17/73/154 V DC)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time > 60 ms.

Output contacts

Quantity Function can be assigned	8 or 16 or 24 (refer to ordering code)
Switching capacity Make Break, high-speed trip outputs Break, contacts Break, contacts (for resistive load) Break, contacts (for τ = L/R ≤ 50 ms)	 1000 W/VA 1000 W/VA 30 VA 40 W 25 VA
Switching voltage	250 V
Permissible current	30 A for 0.5 s 5 A continuous
Operating time, approx. NO contact NO/NC contact (selectable) Fast NO contact High-speed NO trip outputs	 8 ms 8 ms 5 ms < 1 ms

LEDs

	Quantity
RUN (green)	1
ERROR (red)	1
Indication (red), function can be assigned	14

Unit design

Housing	7XP20
Dimension	1/2 x 19” or 1/1 x 19” Refer to ordering code, and see dimension drawings, part 16
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing Front Rear For the terminals	 IP 51 IP 51 IP 50 IP 20 with terminal cover put on
Weight Flush-mounting housing 1/2 x 19” 1/1 x 19” Surface-mounting housing 1/2 x 19” 1/1 x 19”	 6 kg 10 kg 11 kg 19 kg

Serial interfaces

Operating interface, front of unit for DIGSI 4

Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1

Time synchronization

DCF77/IRIG-B signal (Format IRIG-B000)

Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)

Technical data

Service/modem interface (operating interface 2)	
(refer to ordering code)	For DIGSI 4 / modem / service
Isolated RS232/RS485	9-pin subminiature connector
Dielectric test	500 V/ 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
Fiber-optic	Integrated ST connector
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance max.	1.5 km
System interface	
(refer to ordering code)	IEC 61850 Ethernet IEC 60870-5-103 PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1000 m at 93.75 kbaud; 100 m at 12 Mbaud
PROFIBUS fiber-optic[2]	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[4]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance	500 kbit/s 1.6 km 1500 kbit/s 530 m
Protection data relay interfaces	
Quantity	Max. 2 (refer to ordering code)
FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors
FO17[1]: for direct connection up to 25 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector
FO18[1]: for direct connection up to 60 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector
FO19[1]: for direct connection up to 100 km[3], 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector

1) For flush-mouting housing.

2) For surface mounting housing.

3) For surface mounting housing the internal fiber-optic module OMA1 will be delivered together with an external repeater.

4) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order Code L0A (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Relay communication equipment	
External communication converter 7XV5662-0AA00 with X21/RS422 or G703.1 interface	
External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 with clock recovery) to the X21/RS422/G703.1 interface of the communication network	Electrical X21/RS422 or G703.1 interface settable by jumper Baud rate settable by jumper
FO interface with 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode fiber to protection relay
Electrical X21/RS422 interface	64/128/512 kbit (settable by jumper) max. 800 m, 15-pin connector to the communication network
Electrical G703.1 interface	64 kbit/s max. 800 m, screw-type terminal to the communication network
External communication converter 7XV5662-0AC00 for pilot wires	
External communication converter for linking the optical 820 nm interface of the unit (FO5/OMA1 option w. clock recovery) to pilot wires.	Typical distance: 15 km
FO interface for 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode fiber to protection relay, 128 kbit
Electrical interface to pilot wires	5 kV-isolated

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) IEEE Std C37.90.0/.1/.2; UL 508 VDE 0435 Further standards see “Individual functions”
Insulation tests	
Standards	IEC 60255–5 and 60870-2-1
High-voltage test (routine test)	
All circuits except for power supply, binary inputs, high-speed outputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Auxiliary voltage, binary inputs and high-speed outputs (routine test)	3.5 kV DC
only isolated communication interfaces and time synchronization interface (routine test)	500 V (r.m.s.), 50 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 Ws, 3 positive and 3 negative impulses in intervals of 5 s

Technical data

Electrical tests (cont'd)	
EMC tests for noise immunity; type tests	
Standards	IEC 60255-6/-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 part 301 DIN VDE 0435-110
High-frequency test IEC 60255-22-1 class III and VDE 0435 Section 303, class III	2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges per s; test duration 2 s, R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2 class IV and IEC 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with HF field, frequency sweep IEC 60255-22-3 (report) class III IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz: 80 % AM; 1 kHz 10 V/m; 800 to 960 MHz: 80 % AM; 1 kHz 10 V/m; 1.4 to 2 GHz: 80 % AM; 1 kHz
Irradiation with HF field, single frequencies IEC 60255-22-31, IEC 61000-4-3, class III amplitude/pulse modulated	10 V/m; 80, 160, 450. 900 MHz; 80 % AM; 1 kHz; duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III Auxiliary supply	Impulse: 1.2/50 µs Common mode: 2 kV; 12 Ω; 9 µF Differential mode:1 kV; 2 Ω; 18 µF
Analog measurement inputs, binary inputs, relays output	Common mode: 2 kV; 42 Ω; 0.5 µF Differential mode: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power system frequency magnetic field IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability, IEEE Std C37.90.1	2.5 kV (peak); 1 MHz τ = 50 µs; 400 surges per second, test duration 2 s, R_i = 200 Ω
Fast transient surge withstand capability, IEEE Std C37.90.1	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms repition rate 300 ms, ; both polarities; test duration 1 min; R_i = 50 Ω
Radiated electromagnetic interference IEEE Std C37.90.2	35 V/m; 25 to 1000 MHz, amplitude and pulse-modulated
Damped oscillations IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; R_i = 200 Ω
EMC tests for noise emission; type test	
Standard	EN 61000-6-3 (generic standard)
Radio noise voltage to lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress test	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255–21 and IEC 60068–2
Oscillation IEC 60255–21–1, class 2 IEC 60068–2–6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255–21–2, class 1 IEC 60068–2–27	Semi-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255–21–2, class 1 IEC 60068–3–3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255–21 and IEC 60068–2
Oscillation IEC 60255–21–1, class 2 IEC 60068–2–6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255–21–2, class 1 IEC 60068–2–27	Semi-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255–21–2, class 1 IEC 60068–2–29	Semi-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress tests	
Standard	IEC 60255-6
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +23 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.

Technical data

Certifications	
UL listing Models with threaded terminals	7SA522*-*A* 7SA522*-*C* 7SA522*-*D*
UL recognition Models with plug-in terminals	7SA522*-*J* 7SA522*-*L* 7SA522*-*M*

Functions	
***Distance protection** (ANSI 21, 21N)*	
Distance protection zones	6, 1 of which as controlled zone, all zones can be set forward or/and reverse
Time stages for tripping delay Setting range 0 to 30 s or deactivated (steps 0.01 s)	6 for multi-phase faults 3 for single-phase faults
Characteristic Selectable separately for phase and ground (earth) faults	(refer to ordering code) quadrilateral and/or MHO
Time range	0.00 to 30 s (step 0.01 s) or deactivated
Line angle φ_L	10 ° to 89 ° (step 1 °)
Inclination angle for quadrilateral characteristic	30° to 90° (step 1°)
Quadrilateral reactance reach X	0.05 to 600 $\Omega_{(1A)}$ / 0.01 to 120 $\Omega_{(5A)}$ (step 0.001 Ω)
Quadrilateral resistance reach R for phase-to-phase faults and phase-to-ground(earth) faults	0.05 to 600 $\Omega_{(1A)}$ / 0.01 to 120 $\Omega_{(5A)}$ (step 0.001Ω)
MHO impedance reach ZR	0.05 to 200 $\Omega_{(1A)}$ / 0.01 to 40 $\Omega_{(5A)}$ (step 0.01 Ω)
Minimum phase current I	0.05 to 4 A $_{(1A)}$ / 0.25 to 20 A $_{(5A)}$ (step 0.01 A)
Ground(earth)-fault pickup Neutral (residual) current 3 I_0 (Ground current)	0.05 to 4 A $_{(1A)}$ / 0.25 to 20 A $_{(5A)}$ (step 0.01 A)
Zero-sequence voltage 3V_0	1 to 100 V (step 1V) or deactivated
Zero-sequence compensation selectable input formats	R_E/R_L and X_E/X_L k_0 and $\varphi(k_0)$
Separately selectable for zones	Z1 higher zones (Z1B, Z2 to Z5)
R_E/R_L and X_E/X_L	-0.33 to 7 (step 0.01)
k_0 $\varphi(k_0)$	0 to 4 (step 0.001) -135 to 135 ° (steps 0.01 °)
Parallel line mutual compensation R_M/R_L and X_M/X_L	(refer to ordering code) 0.00 to 8 (step 0.01)
Load encroachment Minimum load resistance	0.10 to 600 $\Omega_{(1A)}$ / 0.02 to 120 $\Omega_{(5A)}$ (step 0.001 Ω) or deactivated
Maximum load angle	20 to 60 ° (step 1 °)
Directional decision for all types of faults	With sound phase polarization and/or voltage memory
Directional sensitivity	Dynamically unlimited

Tolerances	For sinusoidal quantities $\left\|\frac{\Delta X}{X}\right\| \leq 5\,\%$ for $30° \leq \varphi_{SC} \leq 90°$ $\left\|\frac{\Delta R}{R}\right\| \leq 5\,\%$ for $0° \leq \varphi_{SC} \leq 60°$ $\left\|\frac{\Delta Z}{Z}\right\| \leq 5\,\%$ for $-30° \leq (\varphi_{SC} - \varphi_{line}) \leq +30°$
Timer tolerance	± 1 % of set value or 10 ms
Operating times Minimum trip time with fast relays Minimum trip time with high-speed relays Reset time	 Approx. 17 ms at 50 Hz Approx. 15 ms at 60 Hz Approx. 12 ms at 50 Hz Approx. 10 ms at 60 Hz Approx. 30 ms
Fault locator	
Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or miles Distance in % of line length
Start of calculation	With trip, with pickup reset
Reactance per unit length	0.005 to 6.5 Ω / $km_{(1A)}$ / 0.001 to 1.3 Ω / $km_{(5A)}$ or 0.005 to 10 Ω / mile $_{(1A)}$ / 0.001 to 2 Ω / mile $_{(5A)}$ (step 0.001 Ω / unit)
Tolerance	For sinusoidal quantities ≤ 2.5 % line length for $30° \leq \varphi_{SC} \leq 90°$ and $V_{SC}/V_N > 0.10$
BCD-coded output of fault location	
Indicated value	Fault location in % of the line length
Output signals	Max. 10: d[1 %], d[2 %], d[4 %], d[8 %], d[10 %], d[20 %], d[401 %], d[80 %], d[100 %], d[release]
Indication range	0 % to 195 %
***Power swing detection** (ANSI 68, 68T)*	
Power swing detection principle	Measurement of the rate of impedance vector change and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping (out-of-step tripping)
Power swing blocking programs	All zones blocked Z1/Z1B blocked Z2 to Z5 blocked Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults

Technical data

***Tele (pilot) protection for distance protection** (ANSI 85-21)*	
Operating modes	POTT PUTT, DUTT Directional comparison: Blocking Directional comparison: Unblocking Directional comparison hybrid (POTT and echo with weak-infeed protection)
Transient blocking logic (current reversal guard)	For overreaching schemes
Send and receive signals	Suitable for 2- and 3- terminal lines, phase-segregated signals for selective single-phase tripping selectable
Direct transfer trip (DTT)	
Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure
Trip time delay	0.00 to 30 s (step 0.01 s) or deactivated
Timer tolerance	± 1 % of setting value or 10 ms
***Directional ground(earth)-fault overcurrent protection** (ANSI 50N, 51N, 67N)*	
Characteristics	3 definite-time stages / 1 inverse-time stage or 4 definite-time stages
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults selectable for every stage
Inrush restraint	Selectable for every stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Influence of harmonics Stages 1 and 2 (I>>> and I>>)	 3rd and higher harmonics are completely suppressed by digital filtering
Stages 3 and 4 (I> and inverse 4th stage)	2nd and higher harmonics are completely suppressed by digital filtering
Definite-time stage	
Pickup definite-time stage 1, $3I_0$	0.05 to 25 A(1A) / 0.25 to 125 A(5A) (step 0.01 A)
Pickup definite-time stage 2, $3I_0$	0.05 to 25 A(1A) / 0.25 to 125 A(5A) (step 0.01 A)
Pickup definite-time stage 3, $3I_0$	0.05 to 25 A(1A) / 0.25 to 125 A(5A) (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 25 A(1A) / 0.015 to 125 A(5A) (step 0.01 A) With high sensitive neutral (residual) current CT (refer to ordering code)
Pickup definite-time stage 4, $3I_0$	0.05 to 4 A(1A) / 0.25 to 20 A(5A) (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 4 A(1A) / 0.015 to 20 A(5A) (step 0.01 A) With high sensitive neutral (residual) current CT (refer to ordering code)
Time delay for definite-time stages	0.00 to 30 s (step 0.01 s) or deactivated
Tolerances Current starting Delay times	 ≤ 3 % of setting value or 1 % of I_{nom} ± 1 % of setting value or 10 ms
Pickup times Definite-time stages 1 and 2 Definite-time stages 3 and 4	 Approx. 30 ms Approx. 40 ms

Inverse-time stage	
Current starting inverse-time stage $3I_0$	0.05 to 4 A(1A) / 0.25 to 20 A(5A) (step 0.01 A) With normal neutral (residual) current CT (refer to ordering code) 0.003 to 4 A(1A) / 0.015 to 20 A(5A) (step 0.001 A) With high sensitive neutral (residual) current CT (refer to ordering code)
Characteristics according to IEC 60255-3	Normal inverse, very inverse, extremely inverse, long time inverse,
Time multiplier for IEC T characteristics	T_p = 0.05 to 3 s (step 0.01s) or deactivated
Pickup threshold	Approx. 1.1 x I / I_p
Reset threshold	Approx. 1.05 x I / I_p
Tolerances Operating time for 2 ≤ I / I_p ≤ 20	 ≤ 5 % of setpoint ± 15 ms
Characteristics according to ANSI/IEEE	Inverse, short inverse, long inverse, moderately inverse, very inverse, extremely inverse, definite inverse
Time dial	0.50 to 15 s (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 x M
Reset threshold	Approx. 1.05 x M
Tolerances Operating time for 2 ≤ M ≤ 20	 ≤ 5 % of setpoint ± 15 ms
Characteristic according to logarithmic inverse characteristic	$t = T_{3I_{0p}\max} - T_{3I_{0p}} \ln \frac{3I_0}{3I_{0p}}$
Pickup threshold	1.1 to 4.0 x I / I_p (step 0.1)
Characteristic according to compensated zero-sequence power	$S_r = 3I_0 \cdot 3V_0 \cdot \cos(\varphi - \varphi_{comp.})$
Polarizing quantities for directional decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_E (grounded (earthed) power transformer) or $3I_2$ and $3V_2$ (negative sequence) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Ground (earth) current I_E of grounded (earthed) power transformer	0.05 to 1 A(1A) / 0.25 to 5 A(5A) (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A(1A) / 0.25 to 5 A(5A) (step 0.01 A)
2nd harmonic ratio for inrush restraint	10 to 45 % of fundamental (step 1 %)
Maximum current, overriding inrush restraint	0.5 to 25 A(1A) / 2.5 to 125 A(5A) (step 0.01 A)
***Tele (pilot) protection for directional ground(earth)-fault overcurrent protection** (ANSI 85-67N)*	
Operating modes	Directional comparison: Pickup Directional comparison: Blocking Directional comparison: Unblocking
Transient blocking logic	For schemes with parallel lines
Send and receive signals	Suitable for 2- and 3- terminal lines

Technical data

Weak-infeed protection with undervoltage (ANSI 27WI)

Operating modes with carrier (signal) reception	Echo Echo and trip with undervoltage
Undervoltage phase – ground (earth)	2 to 70 V (step 1 V)
Time delay	0.00 to 30 s (step 0.01 s)
Echo impulse	0.00 to 30 s (step 0.01 s)
Tolerances Voltage threshold Timer	 ≤ 5 % of setting value or 0.5 V ± 1 % of setting value or 10 ms

Backup overcurrent protection (ANSI 50N, 51N, 67)

Operating modes	Active only with loss of VT secondary circuit or always active
Characteristic	2 definite-time stages /1 inverse-time stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Definite-time stage	
Pickup definite-time stage 1, phase current	0.1 to 25 $A_{(1A)}$ / 0.5 to 125 $A_{(5A)}$ (step 0.01 A)
Pickup definite-time stage 1, neutral (residual) current	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01A)
Pickup definite-time stage 2, phase current	0.1 to 25 $A_{(1A)}$ / 0.5 to 125 $A_{(5A)}$ (step 0.01A)
Pickup definite-time stage 2, neutral (residual) current	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01 A)
Time delay for definite-time stages	0.0 to 30 s (step 0.01 s) or deactivated
Tolerances Current starting Delay times	 ≤ 3 % of setting value or 1 % of I_{nom} ± 1 % of setting value or 10 ms
Operating time	Approx. 25 ms
Inverse-time stage	
Phase current starting for inverse-time stage	0.1 to 4 $A_{(1A)}$ / 0.5 to 20 $A_{(5A)}$ (step 0.01 A)
Neutral (residual) current starting for inverse-time stage	0.05 to 4 $A_{(1A)}$ / 0.25 to 20 $A_{(5A)}$ (step 0.01 A)
Characteristic according to IEC 60255-3	Normal inverse, very inverse, extremely inverse, long time inverse
Time multiplier	T_p = 0.05 to 3 s (step 0.01 s) or deactivated
Pickup threshold	Approx. 1.1 x I / I_p
Reset threshold	Approx. 1.05 x I / I_p
Tolerances Operating time for 2 ≤ I / I_p ≤ 20	 ≤ 5 % of setpoint ± 15 ms
Characteristics according to ANSI/IEEE	Inverse, short inverse, long inverse, moderately inverse, very inverse, extremely inverse, definite inverse
Time dial	D_{IP} 0.50 to 15 s (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 x M (M = I/I_p)
Reset threshold	Approx. 1.05 x M
Tolerances Operating time for 2 ≤ M ≤ 20	 ≤ 5 % of setpoint ± 15 ms

STUB bus overcurrent protection (ANSI 50(N)STUB)

Operating modes	Active only with open isolator position (signaled via binary input)
Characteristic	1 definite-time stage
Instantaneous trip after switch-onto-fault	Selectable
Pickup phase current	0.1 to 25 $A_{(1A)}$ / 0.5 to 125 $A_{(5A)}$ (step 0.01 A)
Pickup neutral (residual) current	0.05 to 25 $A_{(1A)}$ / 0.25 to 125 $A_{(5A)}$ (step 0.01 A)
Time delay, separate for phase and ground (earth) stage	0.00 to 30 s (step 0.01 s) or deactivated
Reset ratio	Approx. 0.95
Tolerances Current starting Delay times	 ≤ 3 % of setting value or 1 % of I_{nom} ± 1 % of setting value or 10 ms

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Operating mode	Active only after CB closing; instantaneous trip after pickup
Pickup current	1 to 25 $A_{(1A)}$ / 5 to 125 $A_{(5A)}$ (step 0.01 A)
Reset ratio	Approx. 0.95
Tolerances Current starting	 ≤ 3 % of setting value or 1 % of I_{nom}
Operating time With fast relays With high-speed trip outputs	 Approx. 13 ms Approx. 8 ms

Voltage protection (ANSI 59, 27)

Operating modes	Local tripping and/or carrier trip impulse for remote end, only indication
Overvoltage protection	
Pickup values V_{PH-Gnd}>>, V_{PH-Gnd}> (phase-earth overvoltage)	1 to 170 V (step 0.1 V)
Pickup values V_{PH-PH}>>, V_{PH-PH}> (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $3V_0$>>, $3V_0$> ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Pickup values V_1>>, V_1> (positive-sequence overvoltage)	2 to 220 V (step 0.1 V)
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values V_2>>, V_2> (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Reset ratio (settable)	0.5 to 0.98 (step 0.01)

Technical data

Undervoltage protection	
Pickup values V_{PH-E}<<, V_{PH-E}< (phase-earth undervoltage)	1 to 100 V (step 0.1 V)
Pickup values V_{PH-PH}<<, V_{PH-PH}< (phase-phase undervoltage)	1 to 170 V (step 0.1 V)
Pickup values V_1<<, V_1< (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio (settable)	1.01 to 1.20 (step 0.01)
Time delays	
Time delay for 3 V_0 stages Time delay for all other over- and undervoltage stages	0 to 100 s (step 0.01 s)or deactivated 0 to 30 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Command/pickup time for 3V_0 stages	Approx. 30 ms or 65 ms (settable)
Tolerances Voltage limit values Time stages	 ≤ 3 % of setting value or 0.5 V 1 % of setting value or 10 ms
Frequency protection *(ANSI 81)*	
Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-earth)
Pickup times	Approx. 80 ms
Dropout times Hysteresis Dropout condition	Approx. 80 ms Approx. 20 mHz Voltage = 0 V and current = 0 A
Tolerances Frequency Delay times	 15 mHz for V_{PH-PH}: 50 to 230 V 1 % of the setting value or 10 ms
Breaker failure protection *(ANSI 50BF)*	
Number of stages	2
Pickup of current element	0.05 to 20 $A_{(1A)}$ / 0.25 to 100 $A_{(5A)}$ (step 0.01 A)
Time delays $T1_{1phase}$, $T1_{3phase}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection CB pole discrepancy monitoring
Reset time	12 ms, typical; 25 ms max.
Tolerances Current limit value Time stages	 ≤ 5 % of setting value or 1 % I_{nom} 1 % of setting value or 10 ms

Auto-reclosure *(ANSI 79)*	
Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1- or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times T_{1-PH}, T_{3-PH}, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT Healthy line voltage Dead line	 30 to 90 V (step 1 V) 2 to 70 V (step 1 V)
Tolerances Time stages Voltage limit values	 1 % of setting value or 10 ms ≤ 3 % of setting value or 0.5 V
Synchro-check *(ANSI 25)*	
Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes with auto-reclosure	 Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1 °)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Tolerances Time stages Voltage limit values	 1 % of setting value or 10 ms ≤ 2 % of setting value or 2 V
Trip circuit supervision *(ANSI 74TC)*	
Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Technical data

Additional functions	
Operational measured values	
Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; $I_{Gnd\ sensitive}$; I_1; I_2; I_Y; 3_{I0PAR}
Tolerances	Typical 0.3 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{Phase\text{-}Ground}$; 3 x $V_{Phase\text{-}Phase}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}
Tolerances	Typical 0.25 % of indicated measured value or 0.01 V_{nom}
Power with direction indication	P, Q, S
Tolerances	
P: for $\lvert\cos\varphi\rvert$ = 0.7 to 1 and V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
Q: for $\lvert\sin\varphi\rvert$ = 0.7 to 1 and V/V_{nom} , I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
S: for V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
Frequency	f
Tolerance	≤ 20 mHz
Power factor	p.f. (cos φ)
Tolerance for $\lvert\cos\varphi\rvert$ = 0.7 to 1	Typical ≤ 3 %
Load impedances with directional indication	3 x $R_{Phase\text{-}Ground}$, $X_{Phase\text{-}Ground}$ 3 x $R_{Phase\text{-}Phase}$, $X_{Phase\text{-}Phase}$
Long-term mean values	
Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every ¼ hour; every ½ hour; every hour
Values	3 x I_{Phase}; I_1; P; P+; P-; Q; Q+; Q-; S
Minimum/maximum memory	
Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values	
Min./max. of measured values	3 x I_{Phase}; I_1; 3 x $V_{Phase\text{-}Ground}$; 3 x $V_{Phase\text{-}to\text{-}phase}$; $3V_0$; V_1; P+; P–; Q+; Q–; S; f; power factor (+); power factor (–)
Min./max. of mean values	3 x I_{Phase}; I_1; P; Q; S
Energy meters	
Four-quadrant meters	W_{P+}; $W_{P–}$; W_{Q+}; $W_{Q–}$
Tolerance	
for $\lvert\cos\varphi\rvert$ > 0.7 and V > 50 % V_{nom} and I> 50 % I_{nom}	5 %
Oscillographic fault recording	
Analog channels	3 x I_{Phase}, $3I_0$, $3I_{0\ PAR}$ 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	> 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	40

Control	
Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys
Remote control	Control protection, DIGSI, pilot wires
Further additional functions	
Measurement supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor Power direction
Annunciations	
Event logging	Buffer size 200
Fault logging	Storage of signals of the last 8 faults, buffer size 600
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle 3-phase TRIP/CLOSE cycle per phase
Setting range	
Dead time for c.b. TRIP/CLOSE cycle	0.00 to 30 s (step 0.01 s)
Commissioning support	Operational measured values, CB. test, status display of binary indication inputs, setting of output relays, generation of indications for testing serial interfaces
Phase rotation adjustment	Clockwise or anti-clockwise

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

6

Selection and ordering data

Description	Order No.
7SA522 distance protection relay for transmission lines	*7SA522□-□□□□□-□□□□*

see following pages

Current transformer

I_{PH} = 1 A[1)], I_{Gnd} = 1 A (min. = 0.05 A)	1
I_{PH} = 1 A[1)], I_{Gnd} = high sensitive (min. = 0.003 A)	2
I_{PH} = 5 A[1)], I_{Gnd} = 5 A (min. = 0.25 A)	5
I_{PH} = 5 A[1)], I_{Gnd} = high sensitive (min. = 0.003 A)	6

(Order code position 7 = 2 or 6 not available with position 14 = K, M, N, Q)

Rated auxiliary voltage (power supply, binary inputs)

24 to 48 V DC, binary input threshold 17 V DC[3)]	2
60 to 125 V DC[2)], binary input threshold 17 V DC[3)]	4
110 to 250 V DC[2)], 115 V AC, binary input threshold 73 V DC[3)]	5
220 to 250 V DC[2)], 115 V AC, binary input threshold 154 V DC[3)]	6

Binary indication inputs	Signal/command outputs, incl. live status contact	Fast relays	High-speed trip outputs	Housing width referred to 19"	Flush-mounting housing/ screw-type terminals	Flush-mounting housing/ plug-in terminals	Surface-mounting housing/ screw-type terminals	
8	9	7	–	1/2	■			A
8	9	7	–	1/2			■	E
8	9	7	–	1/2		■		J
16	17	7	–	1/1	■			C
16	17	7	–	1/1			■	G
16	17	7	–	1/1		■		L
16	16	3	5	1/1	■			N
16	16	3	5	1/1			■	Q
16	16	3	5	1/1		■		S
24	25	7	–	1/1	■			D
24	25	7	–	1/1			■	H
24	25	7	–	1/1		■		M
24	24	3	5	1/1	■			P
24	24	3	5	1/1			■	R
24	24	3	5	1/1		■		T
22	37	7	–	1/1	■			U
24	22	–	10	1/1	■			W

Region-specific default settings/language settings (language selectable)

Region DE, language: German; selectable	A
Region World, language: English (GB); selectable	B
Region US, language: English (US); selectable	C
Region FR, language: French; selectable	D
Region World, language: Spanish; selectable	E
Region World, language: Italian; selectable	F

Regulation on region-specific presettings and function versions:

Region DE: preset to f = 50 Hz and line length in km, only IEC, directional ground-(earth) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r

Region US: preset to f = 60 Hz and line length in miles, ANSI inverse characteristic only, directional ground-(earth) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r, no U_0 inverse characteristic

Region World: preset to f = 50 Hz and line length in km, directional ground-(earth) fault protection: no direction decision with zero-sequence S_r, no U_0 inverse characteristic

Region FR: preset to f = 50 Hz and line length in km, directional ground-(earth) fault protection: no U_0 inverse characteristic, no logarithmic inverse characteristic, weak infeed logic selectable between French specification and World specification.

1) Rated current can be selected by means of jumpers.
2) Transition between the three auxiliary voltage ranges can be selected by means of jumpers.
3) The binary input thresholds can be selected by means of jumpers.

Selection and ordering data

Description	Order No.	Order Code
7SA522 distance protection relay for transmission lines	7SA522□-□□□□□-□□□□ (positions 12–15: see following pages)	□□□
Port B		
Empty	0	
System interface, IEC 60870-5-103 protocol, electrical RS232	1	
System interface, IEC 60870-5-103 protocol, electrical RS485	2	
System interface, IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
System interface, PROFIBUS-FMS Slave, electrical RS485 1)	4	
System interface, PROFIBUS-FMS Slave, optical, double ring, ST connector 1)2)	6	
System interface, PROFIBUS-DP Slave, RS485	9	L 0 A
System interface, PROFIBUS-DP Slave, 820 nm optical, double ring, ST connector 2)	9	L 0 B
System interface, DNP 3.0, RS485	9	L 0 G
System interface, DNP 3.0, 820 nm optical, ST connector 2)	9	L 0 H
System interface, IEC 61850, 100 Mbit/s Ethernet, electrical, duplicate, RJ45 plug connector	9	L 0 R
System interface, IEC 61850, 100 Mbit/s Ethernet, optical, double, ST connector 5)	9	L 0 S
Port C and/or Port D		
Empty	0	
Port C: DIGSI/modem, electrical RS232; Port D: empty	1	
Port C: DIGSI/modem, electrical RS485; Port D: empty	2	
Port C: DIGSI/modem, optical 820 nm, ST connector; Port D: empty	3	
With Port D	9	M □ □
Port C		
Empty		0
DIGSI/modem, electrical RS232		1
DIGSI/modem, electrical RS485		2
DIGSI/modem, optical 820 nm, ST connector		3
Port D		
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 1.5 km For direct connection via multi-mode FO cable or communication networks 3)		A
Protection data interface: optical 820 nm, two ST connectors, FO cable length up to 3.5 km For direct connection via multi-mode FO cable		B
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 25 km for direct connection via mono-mode FO cable 4)		G
Protection data interface: optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable 4)		H
Protection data interface: optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable 4)		J

1) For SICAM energy automation system.
2) Optical double ring interfaces are not available with surface-mounting housings. Please, order the version with RS485 interface and a separate electrical/ optical converter.
3) Suitable communication converters 7XV5662 (optical to G703.1/X21/ RS422 or optical to pilot wire or optical to ISDN) see "Accessories".
4) For surface-mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.
5) Not available with position 9 = "B"

Selection and ordering data

Description	Order No.	Order Code
7SA522 distance protection relay for transmission lines	7SA522□-□□□□□-□□□□	□□□
Functions 1 and Port E		see next page
Trip mode 3-pole; Port E: empty	0	
Trip mode 3-pole; BCD-coded output for fault location, Port E: empty	1	
Trip mode 1 and 3-pole; Port E: empty	4	
Trip mode 1 and 3-pole; BCD-coded output for fault location, Port E: empty	5	
With Port E	9	N□□
Functions 1		
Trip mode 3-pole		0
Trip mode 3-pole; BCD-coded output for fault location		1
Trip mode 1 and 3-pole		4
Trip mode 1 and 3-pole; BCD-coded output for fault location		5
Port E		
Protection data interface optical 820 nm, 2 ST connectors, FO cable length up to 1.5 km For communication networks[1] or direct connection via multi-mode FO cable		A
Protection data interface optical 820 nm, 2 ST connectors, FO cable length up to 3.5 km For direct connection via multi-mode FO cable		B
Protection data interface optical 1300 nm, LC-Duplex connector FO cable length up to 25 km for direct connection via mono-mode FO cable[2]		G
Protection data interface optical 1300 nm, LC-Duplex connector FO cable length up to 60 km for direct connection via mono-mode FO cable[2]		H
Protection data interface optical 1550 nm, LC-Duplex connector FO cable length up to 100 km for direct connection via mono-mode FO cable[2]		J

6

1) Suitable communication converters 7XV5662 (optical to G703.1/X21/ RS422 or optical to pilot wire) see "Accessories".

2) For surface -mounting housing applications an internal fiber-optic module 820 nm will be delivered in combination with an external repeater.

Selection and ordering data

Description	Order No.
7SA522 distance protection relay for transmission lines	*7SA522□-□□□□□-□□□□*

Functions 2

Distance protection characteristic (ANSI 21, 21N)	Power swing detection (ANSI 68, 68T)	Parallel line compensation	
Quadrilateral			C
Quadrilateral and/or MHO			E
Quadrilateral	■		F
Quadrilateral and/or MHO	■		H
Quadrilateral		■[1]	K
Quadrilateral and/or MHO		■[1]	M
Quadrilateral	■	■[1]	N
Quadrilateral and/or MHO	■	■[1]	Q

Functions 3

Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	Breaker failure protection (ANSI 50BF)	Over-/undervoltage protection (ANSI 27, 59) Over-/underfrequency protection (ANSI 81)	
				A
			■	B
		■		C
		■	■	D
	■			E
	■		■	F
	■	■		G
	■	■	■	H
■				J
■			■	K
■		■		L
■		■	■	M
■	■			N
■	■		■	P
■	■	■		Q
■	■	■	■	R

Functions 4

Direction ground(earth)-fault protection, grounded (earthed) networks (ANSI 50N, 51N, 67N)	Measured values, extended Min, max, mean	
		0
	■	1
■		4
■	■	5

1) Only with position 7 of Order No. = *1* or *5*.

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional, device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC61850 system configurator	7XS5403-0AA00
IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14
Manual for 7SA522 English, V4.61 and higher	C53000-G1176-C155-5
Opto-electric communication converters	
Optical to X21/RS422 or G703.1	7XV5662-0AA00
Optical to pilot wires	7XV5662-0AC00
Additional interface modules	
Protection data interface FO 5, OMA1, 820 nm, multi-mode FO cable, ST connector, 1.5 km	C53207-A351-D651-1
Protection data interface FO 6, OMA2, 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
Protection data interface FO 17, 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	C53207-A322-B115-3
Protection data interface FO 18, 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A322-B116-3
Protection data interface FO 19, 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A322-B117-3
Optical repeaters	
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 25 km	7XV5461-0BG00
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00

Accessories

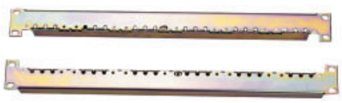


Fig. 6/78 Mounting rail for 19" rack

Fig. 6/79
2-pin connector

Fig. 6/80
3-pin connector

Fig. 6/81
Short-circuit link for current contacts

Fig. 6/82
Short-circuit link for voltage contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	C73334-A1-C35-1	1	Siemens	6/79
	3-pin	C73334-A1-C36-1	1	Siemens	6/80
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP [1]	
		0-827396-1	1	AMP [1]	
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP [1]	
		0-827397-1	1	AMP [1]	
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP [1]	
		0-163084-2	1	AMP [1]	
Crimping tool	For Type III+	0-539635-1	1	AMP [1]	
	and matching female	0-539668-2		AMP [1]	
	For CI2	0-734372-1	1	AMP [1]	
	and matching female	1-734387-1		AMP [1]	
19"-mounting rail		C73165-A63-D200-1	1	Siemens	6/78
Short-circuit links	For current terminals	C73334-A1-C33-1	1	Siemens	6/81
	For other terminals	C73334-A1-C34-1	1	Siemens	6/82
Safety cover for terminals	Large	C73334-A1-C31-1	1	Siemens	6/52
	Small	C73334-A1-C32-1	1	Siemens	6/52

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram, IEC

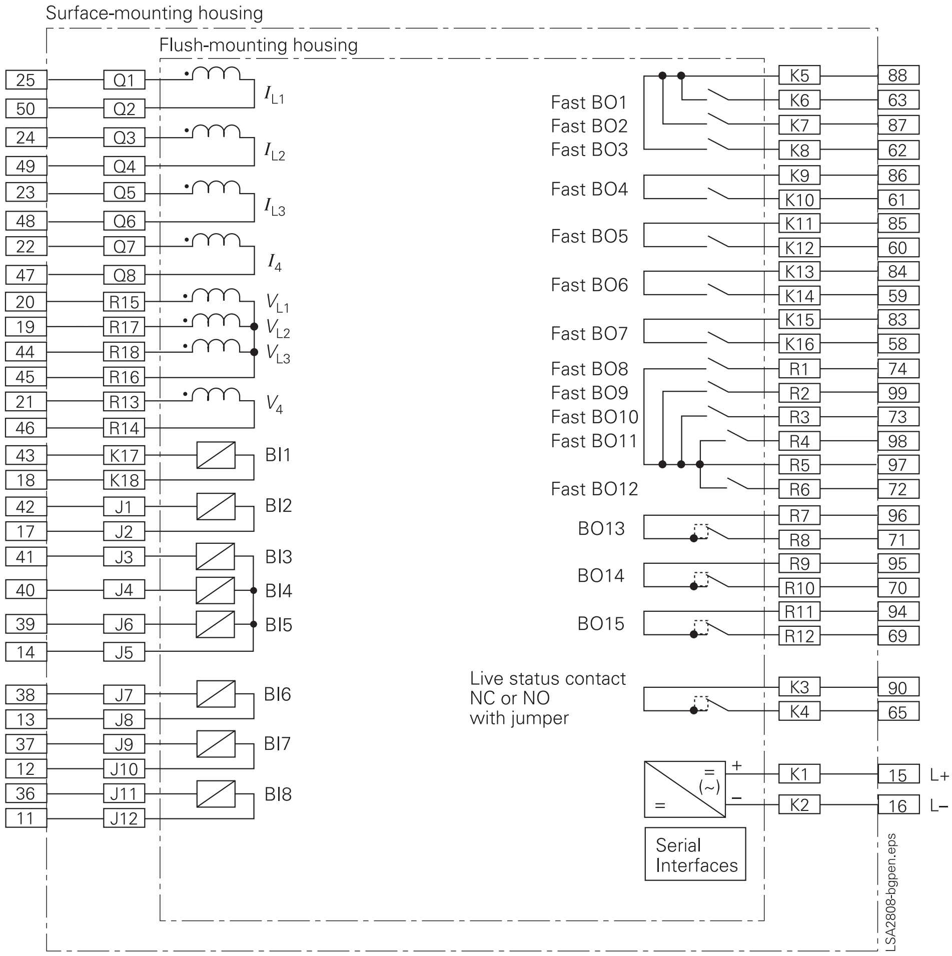


Fig. 6/83
Housing 1/2 x 19", basic version 7SA522x-xA, 7SA522x-xE and 7SA522x-xJ with 8 binary inputs and 16 binary outputs, hardware version .../FF

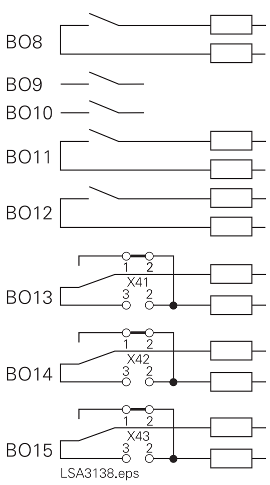


Fig. 6/83a
Additional setting by jumpers:
Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

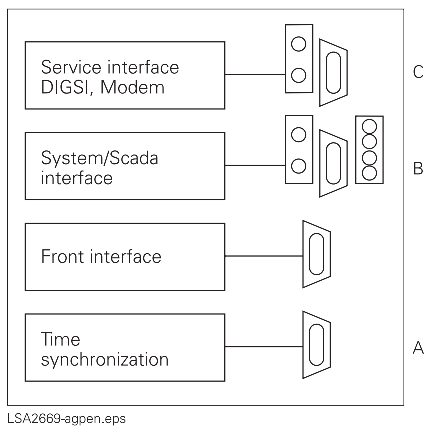


Fig. 6/84
Serial interfaces

Connection diagram, IEC

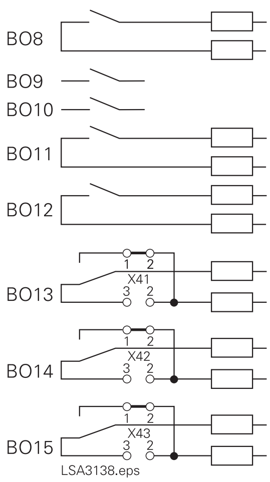


Fig. 6/85a
Additional setting by jumpers:
Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82.
Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

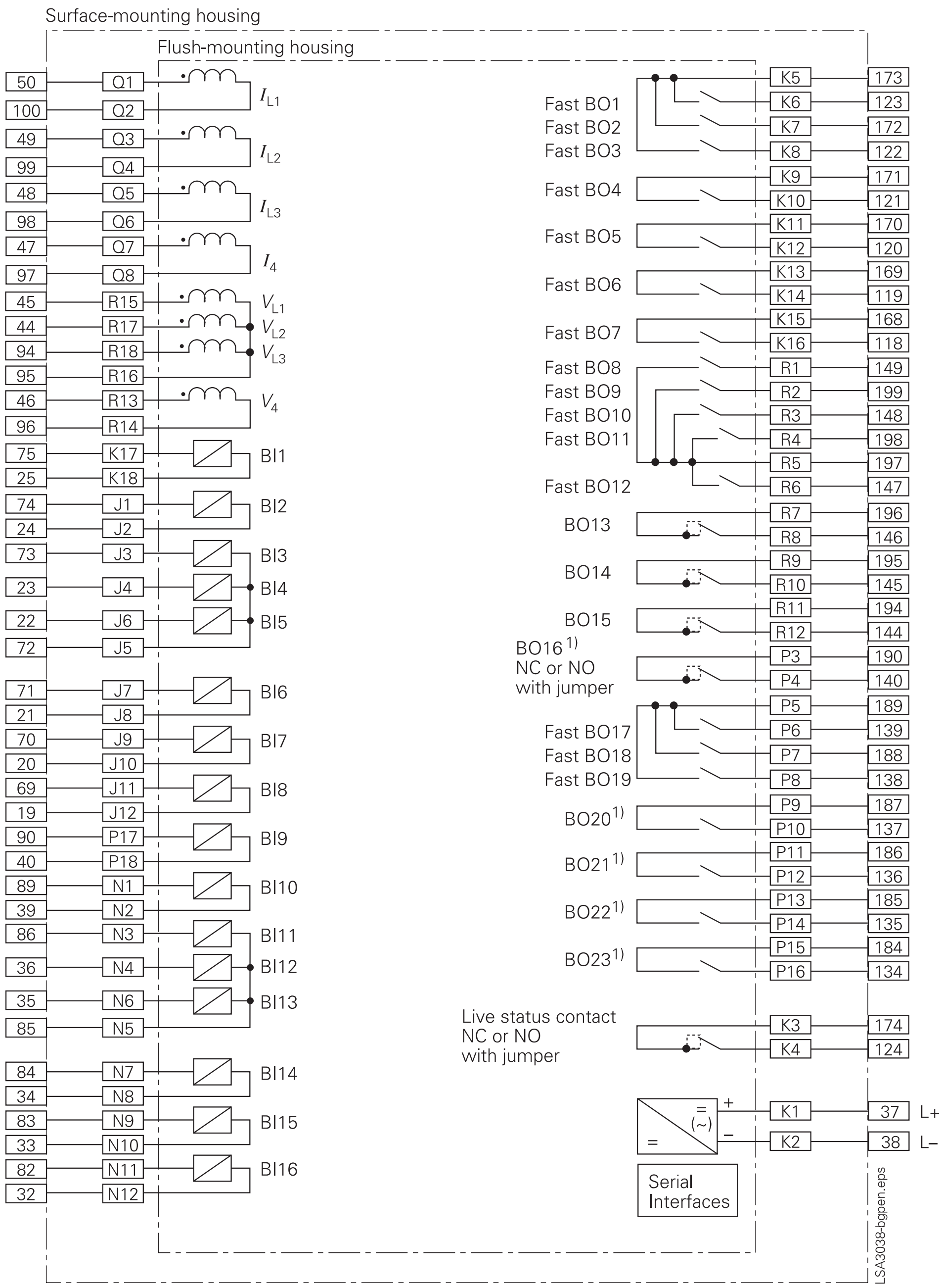


Fig. 6/85
Housing 1/1 x 19", medium version 7SA522x-xC, 7SA522x-xG, 7SA522x-xL, 7SA522x-xN, 7SA522x-xQ and 7SA522x-xS with 16 binary inputs and 24 binary outputs, hardware version .../FF

1) High-speed trip outputs in versions 7SA522x-xN, 7SA522x-xQ, 7SA522x-xS.

Note: For serial interfaces see Figure 6/84.

Connection diagram, IEC

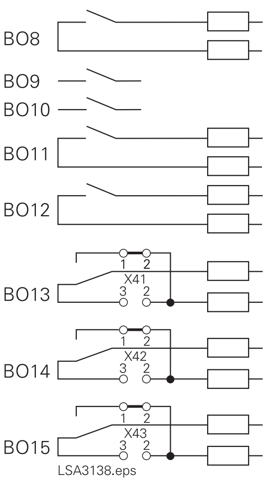


Fig. 6/86a
Additional setting by jumpers:
Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82.
Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

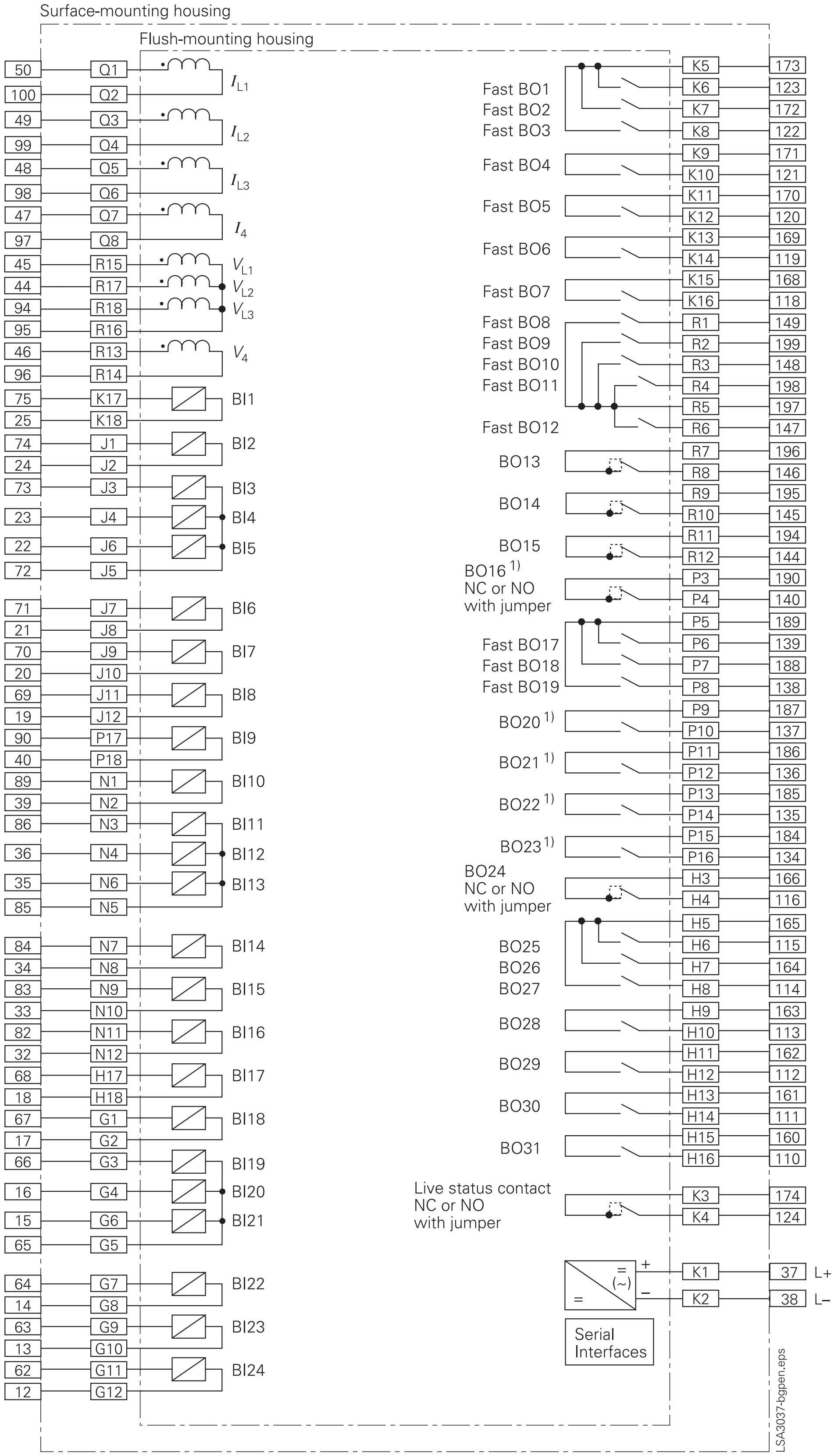


Fig. 6/86
Housing 1/1 x 19", maximum version 7SA522x-xD, 7SA522x-xH, 7SA522x-xM, 7SA522x-xP, 7SA522x-xR and 7SA522x-xT with 24 binary inputs and 32 binary outputs, hardware version .../FF

1) High-speed trip outputs in versions 7SA522x-xP, 7SA522x-xR, 7SA522x-xT.

Note: For serial interfaces see Figure 6/84.

Connection diagram, ANSI

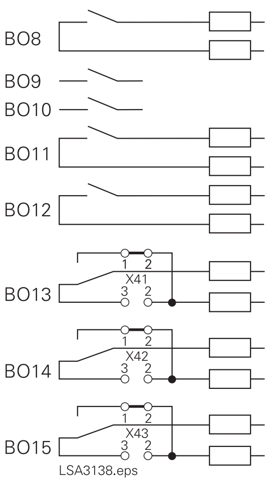


Fig. 6/87a
Additional setting by jumpers: Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

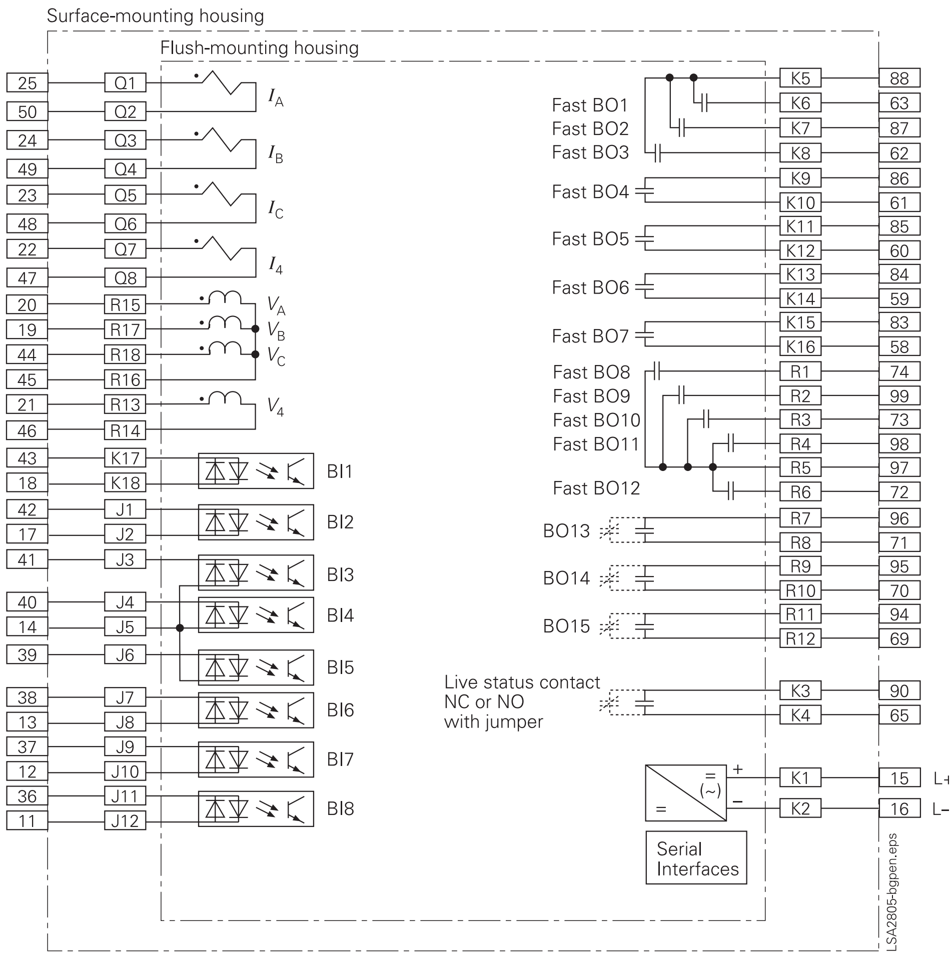


Fig. 6/87
Housing 1/2 x 19", basic version 7SA522x-xA, 7SA522x-xE and 7SA522x-xJ with 8 binary inputs and 16 binary outputs, hardware version .../FF

Note: For serial interfaces see Figure 6/84.

Connection diagram, ANSI

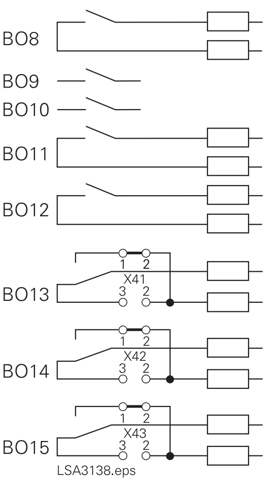


Fig. 6/88a
Additional setting by jumpers:
Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82.
Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.

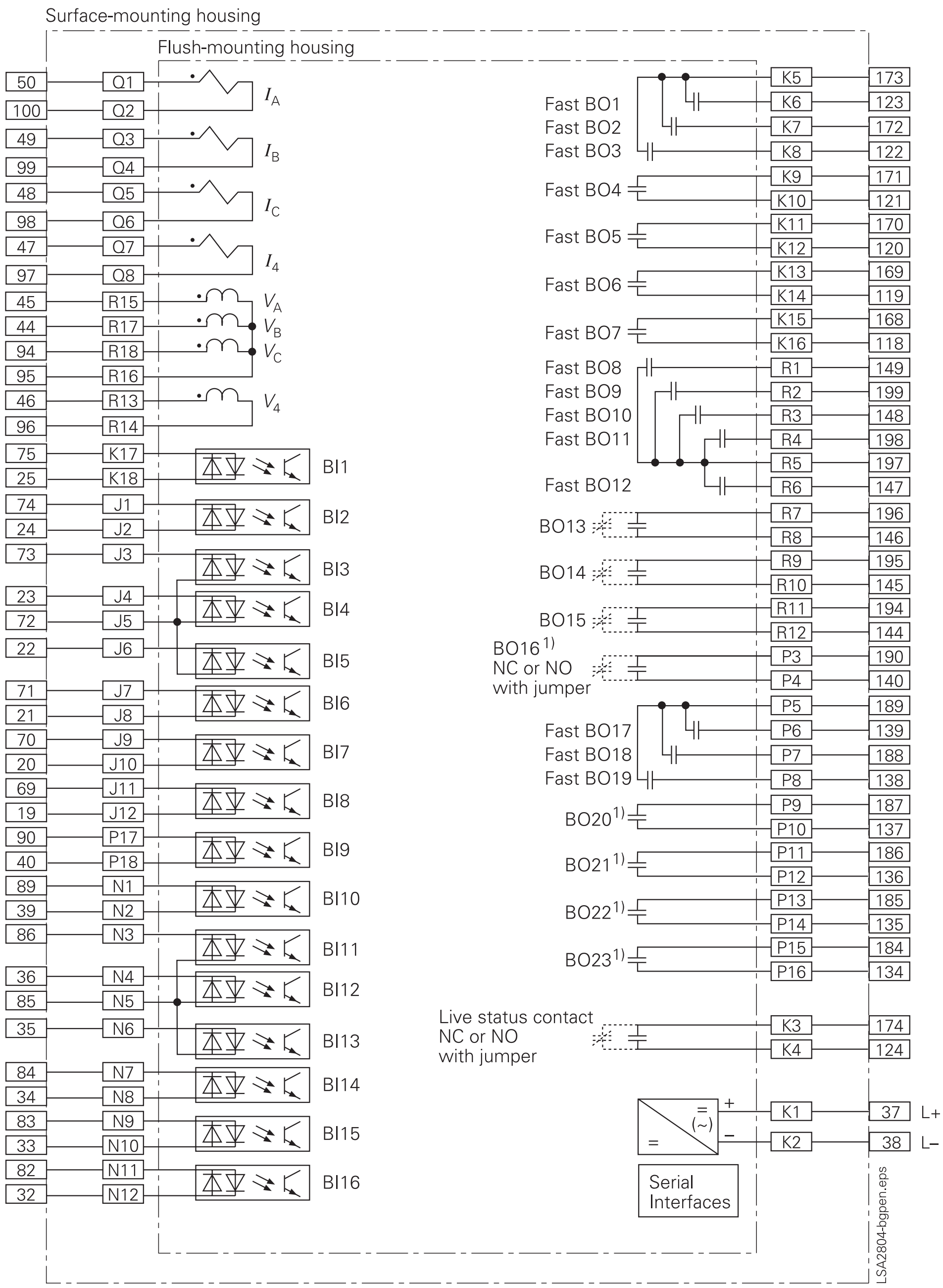


Fig. 6/88
Housing 1/1 x 19", medium version 7SA522x-xC, 7SA522x-xG, 7SA522x-xL, 7SA522x-xN, 7SA522x-xQ and 7SA522x-xS with 16 binary inputs and 24 binary outputs, hardware version .../FF

1) High-speed trip outputs in versions 7SA522x-xN, 7SA522x-xQ, 7SA522x-xS.

Note: For serial interfaces see Figure 6/84.

Connection diagram, ANSI

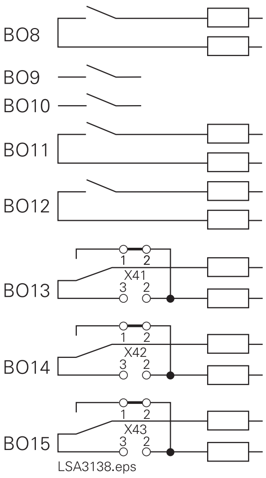
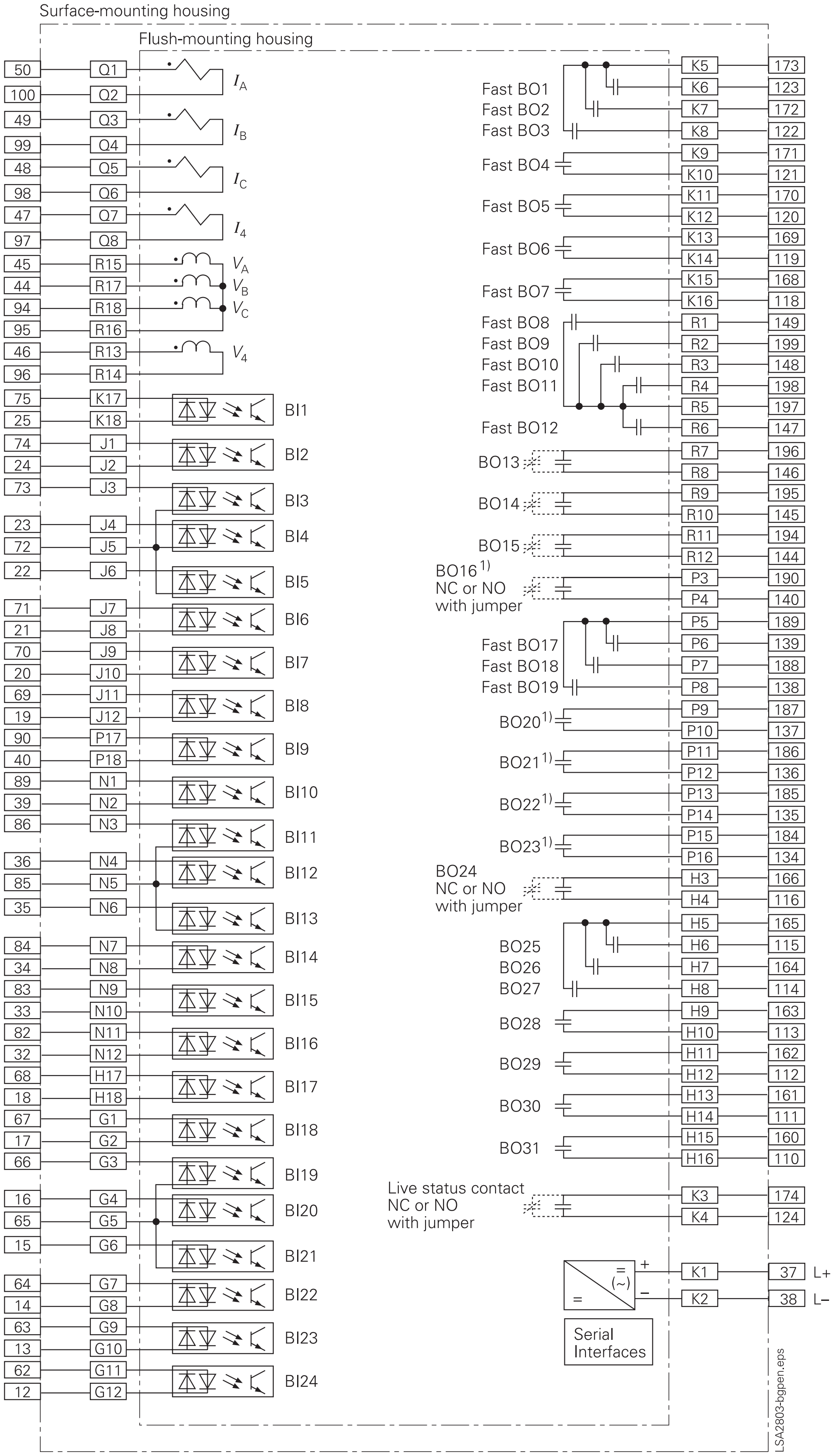


Fig. 6/89a
Additional setting by jumpers:
Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO13, BO14, BO15 as NO contact or NC contact with jumpers.



1) High-speed trip outputs in versions 7SA522x-xP, 7SA522x-xR, 7SA522x-xT.

Note: For serial interfaces see Figure 6/84.

Fig. 6/89
Housing 1/1 x 19", maximum version 7SA522x-xD, 7SA522x-xH and 7SA522x-xM with 24 binary inputs and 32 binary outputs, hardware version ../FF

6

Line Differential Protection

7

SIPROTEC 7SD60
Numerical Pilot-Wire Current Differential Protection Relay

LSP2001-afpen.tif

Fig. 7/1
SIPROTEC 7SD600
numerical current differential protection relay

Description

The 7SD600 relay is a numerical current differential protection relay, simple to set, operating in conjunction with the remote station via a two pilot-wire link. It is connected to the primary current transformers via an external summation current transformer. The primary field of application of the relay is protection of short overhead lines and cables with two line ends. However, transformers and reactors may be located within the protection zone. Features like inrush restraint, lockout, modern PCM-intertrip facilities, full self-monitoring facilities, local and remote interrogation are integrated in the unit.

Function overview

Differential protection relay for overhead lines and cables

- Current differential protection with external summation current transformer 4AM49 (87L)
- Suitable for use for distances of approx. 12 km max. via two pilot wires (1200 Ω loop resistance)
- Differential protection can be combined with an overcurrent release
- Pilot-wire monitoring function
- Bidirectional remote tripping
- Circuit-breaker intertripping at the remote station
- Seal-in of the TRIP command until manual reset (Lockout function)
- Minimal current transformer requirements due to integrated saturation detector
- Restraint against inrush/undelayed trip for high differential fault currents
- Emergency overcurrent protection

Operational measured values

- Local and remote current
- Differential current
- Restraint current

Monitoring functions

- Hardware
- Firmware
- Spill current supervision

Hardware

- Local operation by means of integrated keyboard
- LCD display for settings and analysis
- Housing
  – Flush-mounting housing 1/6 19" 7XP20
  – Surface-mounting housing 1/6 19" 7XP20

Communication

- Via personal computer and DIGSI 3
- Via RS232↔RS485 converter
- With modem
- With substation control system via IEC 60870-5-103 protocol
- 2 kV isolated RS485 interface, bus connection possible

7

Application

The 7SD60 relay is a numerical current differential protection relay, simple to set, and is operated in conjunction with the remote station via a two pilot-wire link.

It is connected to the primary current transformers via an external summation current transformer. The unit operates internally on the summated current taken from the secondary side of the summation current transformer. The link to the remote station is realized by means of a pair of symmetrical pilot wires allowing distances of up to approximately 12 km. Adaptation to the pilot-wire resistance is effected by means of software within the unit. Therefore, matching is not necessary.

The primary field of application of the unit is protection of short overhead lines and cables with two line ends. However, transformers and reactors may be located within the protection zone. The unit can be fitted with inrush restraint in such cases. A differential protection instantaneous tripping stage is also provided in this case. Vector group adaptation is not effected inside the unit and must, if necessary, be effected by means of a matching current transformer.

The 7SD60 can be fitted with a pilot-wire monitoring function. In addition to monitoring the pilot-wire link to the remote station, this also includes bidirectional circuit-breaker intertripping and a remote tripping command.

If the differential protection becomes inactive due to a pilot-wire failure, the relay has an emergency overcurrent function as an option. It includes one definite-time overcurrent stage and can be delayed.

This unit substitutes the 7SD24 steady-state differential protection. However, direct interoperation with the 7SD24 is not possible. On replacement of a 7SD24, its external summation current transformer can be used as the input transformer for the 7SD60.

ANSI	
87L, 87T	ΔI for lines/cables, transformers
85	Intertrip, remote trip
86	Lockout function
50	Single-stage, definite-time emergency overcurrent protection

Construction

The compact 7SD60 protection relay contains all the components for:

- Measured-value acquisition and evaluation
- Operation and LCD indications
- Alarm and command contacts
- Input and evaluation of binary signals
- Data transmission via the RS485 bus interface to DIGSI or a substation control system
- Auxiliary voltage supply

The primary current transformers are connected to the 4AM49 summation current transformer. At the rated current value of either 1 A or 5 A, the latter outputs a current of 20 mA which is measured by the 7SD60 unit. The summation current transformer is supplied together with the protection unit, if so ordered.

The unit can be supplied in two different housings. The one for flush mounting in a panel or cubicle has connection terminals at the rear.

The version for panel surface mounting is supplied with terminals accessible from the front. Alternatively, the unit can be supplied with two-tier terminals arranged above and below the unit.

Fig. 7/2
Rear view flush-mounting housing

7

Protection functions

Mode of operation of the differential protection relay

An external summation current transformer 4AM49, which can be supplied as an accessory either in a 1 A or a 5 A version, allows any secondary currents of the primary current transformers (see Fig. 7/3) to be connected. The standard ratios of the three primary windings of the summation current transformer are IL1:IL2:IL3 = 5:3:4 (IL1:IL3:IL0 = 2:1:3) (see Fig. 7/6). In consequence, the sensitivity of the tripping characteristic for single-phase faults is appreciably higher compared to that for two-phase and three-phase faults. Since the current on such faults is often weak, an amplification factor of 1.7 to 2.8 referred to the symmetrical response value is achieved.

Other sensitivity values can, however, be obtained by altering the connections at the summation CT.

With a symmetrical three-phase current of 1 x I_N, the secondary current of the summation current transformer is 20 mA.

The 7SD60 measures and digitalizes the current I_{M1} of the local relay by means of a sensitive current input (see Fig. 7/6). A voltage drop occurs across a fixed-value resistor R_b installed in the unit. With a through-flowing load or a through- flowing short-circuit current, the voltage drop at both ends of the line is approximately equal but of opposite polarity, so that no current flows through the pilot wire. On occurrence of an internal fault, different values are obtained for the voltage drop across R_b at both ends. In consequence, a current I_a flows through the pilot wire, which is measured by means of the current transformer. In conjunction with the pilot- wire resistance (available as a parameter in the unit) and the internal resistor R_a, it is possible to calculate the differential current from the measured current flowing through the pilot wire. As soon as an adjustable value is reached, the protection relay trips the line at both ends.

Matching of the sensitivity of the unit for different values of pilot-wire resistance is effected by the firmware of the unit during parameter setting, so that time-consuming matching of the pilot-wire resistance is unnecessary.

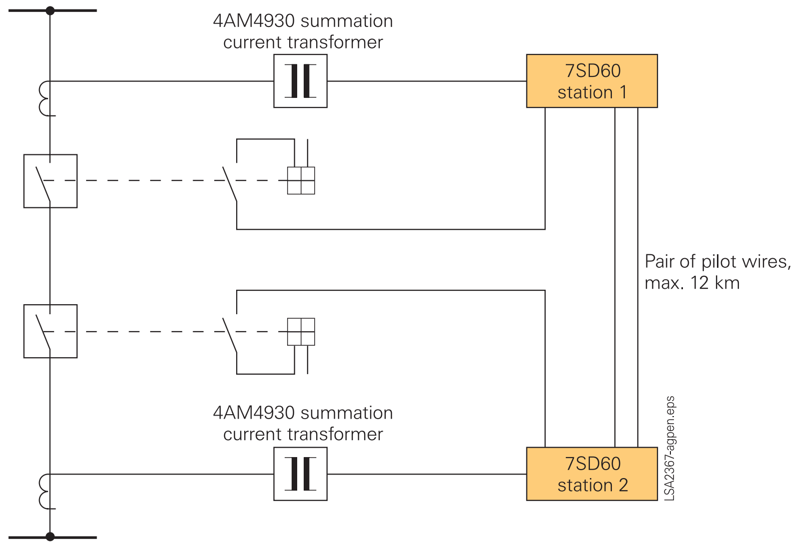
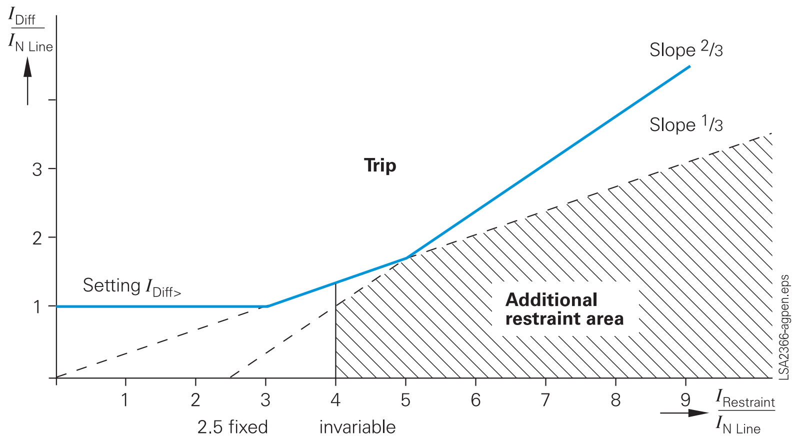


Fig. 7/3
7SD60 line differential protection for operation with two pilot wires



I_{Diff} = $|I_1 + I_2|$
$I_{Restraint}$ = $|I_1| + |I_2|$
I_1 = current at local relay end of line, current flowing into the line is positive
I_2 = current at remote relay, current flowing into the line is positive
$I_{N\ Line}$ = rated current of the line

Fig. 7/4
Trip characteristic of differential protection

Trip characteristic of the differential protection relay

The main function of the unit is current comparison protection. The trip characteristic is fixed and takes into account both the linear and the non-linear errors of the current transformers. It is only necessary to set the tripping value $I_{Diff>}$, although the standard setting is suitable for most applications. It should be parameterized according to the rated current of the line; sensitive setting is possible even when the current transformer rated currents and the line rated currents differ by as much as a factor of 2. Differences in the current transformation ratios at the ends of the line must, however, be compensated for by means of external matching current transformers.

In some cases, this can be realized by the summation current transformer.

Protection functions

Overcurrent release / differential current monitoring

The differential protection function can be combined with an additional overcurrent release. To this end, the criteria “overcurrent” and “differential current” are linked logically so that a TRIP command is given out by the differential function only when a differential current and an overcurrent coexist.

By this means it is often possible to avoid malfunctioning due to pilot-wire short-circuit or wire-break of a connection between a current transformer and the summation current transformer. For this purpose, the 7SD60 is fitted with an additional differential current monitoring function, which can effectively block the differential protection after a delay of some seconds on reaching of an adjustable value of differential current in conjunction with simultaneous operational current I_{M1} within the load range.

Saturation detector

Improved stability on single-ended saturation of the primary current transformers is ensured by means of an integrated saturation detector. It provides additional stability during external faults. 5 ms are enough time to measure an external fault due to a high restraint and small differential current. Indication is done within the additional restraint area (see Fig. 7/4). If – due to CT saturation – the differential current flows into the trip area, the differential trip is blocked for a certain time. Transient saturation of current transformers caused by decaying DC components in the short-circuit current can thus be recognized.

As a result, the requirements on the current transformers are reduced so that they are only required to conduct the steady-state through-flowing short-circuit current without saturation.

Pilot-wire link / pilot-wire monitoring

The link to the remote station comprises a symmetrical pair of wires (e.g. telephone lines). The maximum permissible distance between two stations is approximately 12 km. 7XR9513 (20 kV) or 7XR9515 (5 kV) isolation transformers can be employed for potential isolation against interference induced by longitudinal voltages where the pilot wires run parallel to power cables over long distances.

Since the pilot wires form an integral part of the differential protection, these are normally monitored continuously. This function is available as an option. To achieve this, 2 kHz pulses with a defined pulse width ratio are transmitted to the remote relay via the pilot wires. Detection of a fault in the pilot-wire link results in blocking of the differential protection.

Emergency overcurrent protection

If the differential protection becomes inactive due to a pilot-wire failure or an internal or external blocking of the differential function, the relay offers a single-stage, definite-time overcurrent function. It works with the local flowing operational current I_{M1}. The pickup value and the delay time are settable via parameters in the device.

Circuit-breaker intertripping / remote tripping

Normally, tripping is effected at both stations as a result of current comparison. Tripping at one end only can occur when an overcurrent release is used or with short-circuit currents only slightly above the tripping value. Circuit-breaker intertripping can be parameterized in the unit with integral pilot-wire monitor, so that definite tripping at both ends of the line is assured.

In addition, it is possible by means of a binary input to output a remote tripping command for both directions. The command transmission time is approximately 80 ms.

Lockout of the TRIP command with manual reset

The TRIP command can be locked-out after tripping. In particular, in the case of transformers within the protection zone, reclosure of the line is normally effected only after the cause of the fault has been ascertained by the user. Manual reset is possible either via the operator panel (with password) or via a binary input. As a result, premature reclosure of the circuit-breaker is prevented. The logic state of the TRIP command remains stored even during failure of the auxiliary supply voltage, so that it is still present on restoration of the auxiliary supply voltage.

Inrush restraint / instantaneous tripping stage

Where transformers or reactors are located within the protection zone, inrush restraint can be supplied as an option. This inrush restraint evaluates the second harmonic of the differential current, which is typical for inrush phenomena. If the second harmonic value of the differential current referred to the fundamental frequency exceeds a preset value, tripping by the differential protection is blocked. In the case of high-current internal faults, whose amplitude exceeds the inrush current peak, tripping can be carried out instantaneously.

Vector group adaptation is not effected inside the unit and must, where necessary, be brought about by means of an external matching transformer scheme.

Features

Serial data transmission

As standard, the unit is fitted with an RS485 interface. This is suitable for connection to a bus and allows up to 32 devices to be connected via a two-wire serial interface (use of a third core for earth is recommended). A PC is connected via this interface using an RS232↔RS485 converter, thus allowing the DIGSI operator program to be used, by means of which PC-aided planning, parameter setting and evaluation can be performed. By this readout, it is also possible to output the fault recordings stored by the unit on occurrence of faults.

Using an RS485↔820 nm optical converter as an accessory (7XV5650, 7XV5651), it is possible to provide an interference-free and isolated link to a central control system or a remote control system employing DIGSI, thus allowing economically viable configurations to be used, e.g. for remote diagnostics.

The serial interface can also be set to the IEC 60870-5-103 protocol (VDEW - Association of German Utilities - interface), thus allowing the unit to be integrated in a substation control system. However, only 2 messages (ready for operation and the trip signal) and the fault recording are available.
For this reason, it is recommended to use the 7SD610 unit combined with an external communication converter for pilot wires in those cases in which integration in the substation control system is a prime consideration.

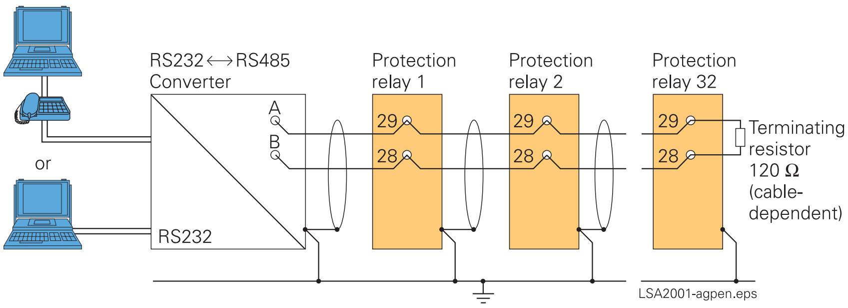


Fig. 7/5
Bus communication via RS485 interface
For convenient wiring of RS485 bus, use bus cable system 7XV5103 (see part 14 of this catalog).

Connection diagrams

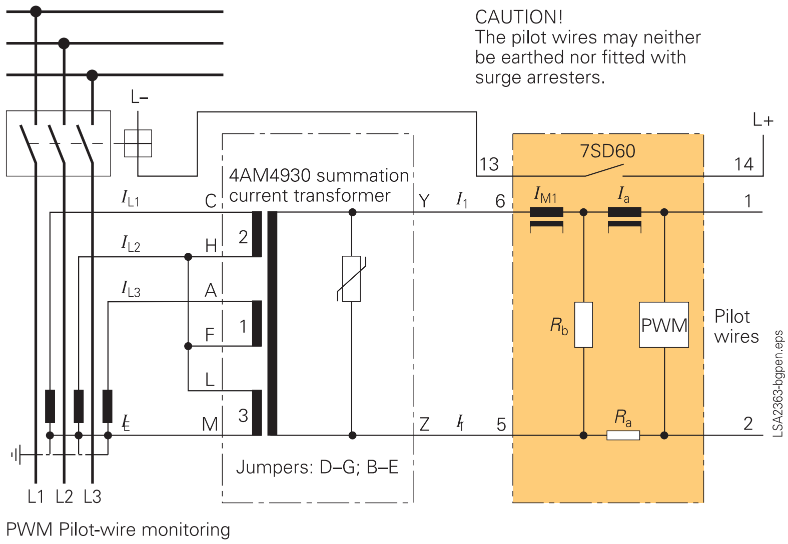


Fig. 7/6
Standard connection L1-L3-E, suitable for all types of networks

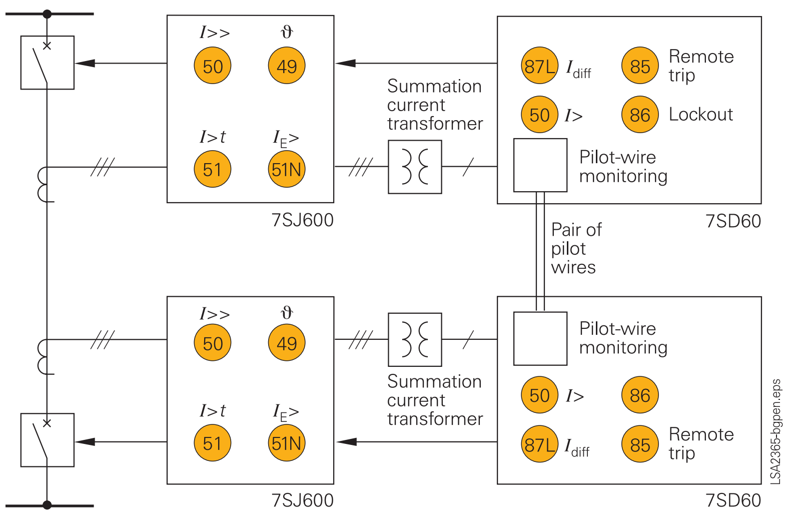


Fig. 7/7
Protection configuration with main (7SD60) and backup overcurrent (7SJ60) protection

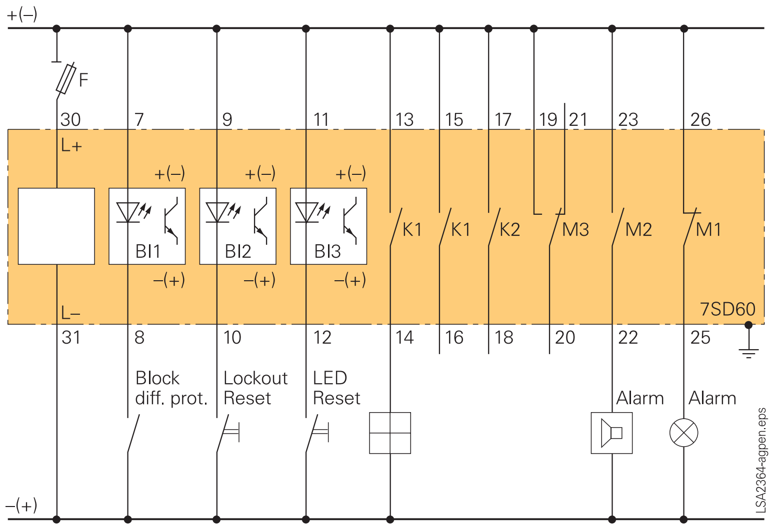


Fig. 7/8
Typical circuit for auxiliary voltage supply

Technical data

General unit data	
Input circuits	
Rated current I_N	20 mA without summation current transformer 1 or 5 A with summation current transformer
Rated frequency f_N	50/60 Hz parameterizable
Thermal overload capability current path Continuous For 10 s For 1 s	 2 x I_N 30 x I_N 100 x I_N
Auxiliary voltage	
Auxiliary voltage via integrated DC/DC converter	
Rated auxiliary DC voltage/ permissible variations	24/48 V DC /19 to 58 V DC 60/110/125 V DC /48 to 150 V DC 220/250 V DC /176 to 300 V DC
Superimposed AC voltage V_{aux} Peak-to-peak	≤ 12 % at rated voltage ≤ 6 % at limits of admissible voltage
Power consumption Quiescent Energized	 Approx. 2 W Approx. 4 W
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms (at V_{aux} ≥ 100 V AC/DC) ≥ 20 ms (at V_{aux} ≥ 24 V DC)
Rated auxiliary voltage AC V_{aux}/ permissible variations	115 V AC / 88 to 133 V AC
Command contacts	
Number of relays	2 (marshallable)
Contacts per relay	2 NO or 1 NO
Switching capacity Make Break	 1000 W/VA 30 W/VA
Switching voltage	250 V
Permissible current Continuous For 0.5 s	 5 A 30 A
Signal contacts	
Number of relays	3 (2 marshallable)
Contacts per relay	1 CO
Switching capacity Make Break	 1000 W/VA 30 W/VA
Switching voltage	250 V AC/DC
Permissible current	5 A

Binary inputs	
Number	3 (marshallable)
Operating voltage	24 to 250 V DC
Current consumption, energized	Approx. 2.5 mA independent of operating voltage
Pick-up threshold reconnectable Rated aux. voltages 24/48/60 V DC $V_{pick\text{-}up}$ $V_{drop\text{-}off}$	By solder bridges ≥ 17 V DC < 8 V DC
Rated aux. voltages 110/125/220/250 V DC $V_{pick\text{-}up}$ $V_{drop\text{-}off}$	 ≥ 74 V DC < 45 V DC
Unit design	
Housing	7XP20
Dimensions	For dimensions, see dimension drawings, part 16
Weight With housing for surface mounting With housing for flush mounting/cubicle mounting	 Approx. 4.5 kg Approx. 4 kg
Degree of protection acc. to EN 60529 Housing Terminals	 IP 51 IP 21
Serial interface (Isolated)	
Standard	RS485
Test voltage	2.8 kV DC for 1 min
Connection	Via wire to housing terminals, 2 data transmission lines, 1 earthing cable for connection to an RS485↔RS232 converter, cables have to be shielded, screen has to be earthed Setting at supply: 9600 baud
Baud rate	Min. 1200 baud; max. 19200 baud

Technical data

Electrical tests	
Specification	
Standards	IEC 60255-5 ANSI/IEEE C37.90.0
Insulation tests	
Voltage test (routine test) All circuits except DC voltage supply and RS485 Only DC voltage supply and RS485	 2 kV (r.m.s.), 50 Hz 2.8 kV DC
Impulse voltage test (type test) All circuits, class III	 5 kV (peak), 1.2/50 µs, 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s
Test crosswise: Measurement circuits, pilot wire connections, power supply, binary inputs, class III, (no tests crosswise over open contacts, RS458 interface terminals)	
EMC tests for noise immunity; *type tests*	
Standards	IEC 60255-6; IEC 60255-22 (international product standard) EN 50082-2 (generic standard) VDE 0435, Part 303 (German product standard)
High-frequency test IEC 60255-22-1, VDE 0435 Part 303; class III	2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges; duration 2 s
Electrostatic discharge IEC 60255-22-2, EN 61000-4-2; class III	4/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 class III	10 V/m 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3; class III	10 V/m 80 to 1000 MHz; AM 80 %; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m, 900 MHz; repetition rate 200 Hz, duty cycle 50 %
Fast transients/bursts IEC 60255-22-3, IEC 61000-4-4, class IV	2 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
Line-conducted RF amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; AM 80 %; 1 kHz
Power frequency magnetic field IEC 61000-4-8; class IV; EN 60255-6	30 A/m; 50 Hz, continuous 300 A/m for 3 s; 50 Hz; 0.5 mT, 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak), 1 MHz to 1.5 MHz decaying oscillation; 50 shots per s; duration 2 s; R_i = 150 Ω to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV; 10/150 ns; 50 shots per s both polarities; duration 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m; 25 to 1000 MHz; amplitude and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity) 100 kHz, 1 MHz, 10 and 50 MHz, decaying oscillation; R_i = 50 Ω
EMC tests for interference emission; *type tests*	
Standard	EN 50081- (generic standard)
Conducted interference voltage on lines, auxiliary voltage only, EN 55022, VDE 0878 Part 22, CISPR 22, limit value, limit class B	150 kHz to 30 MHz
Interference field strength EN 55011, VDE 0875 Part 11, IEC CISPR 11, limit value, limit class A	30 to 1000 MHz

Mechanical dynamic tests	
Vibration, shock stress and seismic vibration	
<u>During operation</u>	
Standards	IEC 60255-21; IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz; ± 0.035 mm amplitude; 60 to 150 Hz; 0.5 *g* acceleration; sweep rate 1 octave/min; 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine 5 *g* acceleration, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-2-6	Sinusoidal 1 to 8 Hz; ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz; ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz; 1 *g* acceleration (horizontal axis) 8 to 35 Hz; 0.5 *g* acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Standards	IEC 60255-21; IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 Hz to 8 Hz: ±7.5 mm amplitude 8 Hz to 150 Hz: 2 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sine Acceleration 15 *g*, duration 11 ms, 3 shocks Shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine Acceleration 10 *g*, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

7

Technical data

Climatic stress test	
Temperatures	
Standards	EN 60255-6, IEC 60255-6 DIN VDE 0435 Part 303
Recommended temperature	-5 to +55 °C (>55 °C/131 °F decreased display contrast)
Limit temperature During service During storage During transport (Storage and transport with standard works packing!)	 -20 to +70 °C - 4 to +158 °F -25 to +55 °C -13 to +131 °F -25 to +70 °C -13 to +158 °F
Humidity	
It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Mean value per year ≤ 75 % relative humidity, on 30 days a year up to 95 % relative humidity, condensation not permissible!

Functions	
Line differential protection	
Note	All current values refer to the symmetrical current using standard connection
Setting ranges Current threshold I_1 (release by local station current) Differential current Delay time t	 $I/I_{N\ Line}$: 0 to 1.5 (step 0.01) $I/I_{N\ Line}$: 0.5 to 2.5 (step 0.01) 0 to 60 s (step 0.01 s)
Restraint by 2nd harmonic (see Fig. 7/4) $2f_N\ /f_N$ Reset ratio	 10 to 80 % Approx. 0.7 – drop-off ratio ($I_{Restraint} = 0$)
Inherent delays TRIP time for two-end supply at 4 x set value	 Approx. 20 to 28 ms without restraint by 2nd harmonic Approx. 32 to 42 ms with restraint by 2nd harmonic
Drop-off time	Approx. 35 ms
Tolerances at preset values under reference conditions Local station current threshold Differential current	 ± 3 % of setpoint, min. 0.02 x I_N ± 5 % of setpoint, min. 0.02 x I_N
Influence parameters Auxiliary supply voltage $0.8 \leq V_{aux}/V_{auxN} \leq$ x 1.15 Temperature in range $0\ °C \leq \Theta_{amb} \leq 40\ °C$ Frequency in range $0.9 \leq f/f_N \leq 1.1$	 ≤ 1 % ≤ 1 %/10 K ≤ 4 %
Pilot wires Number	 2 Symmetric telephone pairs are recommended with loop resistance 73 Ω/km and capacitance 60 nF/km
Core-to-core asymmetry at 800 Hz	Max. 10^{-3}
Maximum loop resistance	1200 Ω
Permissible induced longitudinal voltages On direct connection of the pilot wires For connection via isolating transformer	 ≤ 1.2 kV, however, max. 60 % of the test voltage of the pilot wires ≥ 1.2 kV, however, max. 60 % of the test voltage of the pilot wires and max. 60 % of the test voltage of the isolating transformers

Pilot-wire monitoring and intertripping (optional)	
Monitoring signal	2000 Hz, pulse-code modulation
Alarm signal delay	1 to 60 s (step 1 s)
Inherent delay time of intertripping	Approx. 65 ms
Extension of the intertripping signal	0 to 5 s (step 0.01 s)
Emergency overcurrent protection	
Setting ranges Overcurrent pickup value I_{M1} / I_{Nline} Delay time	 0.1 to 15 (step 0.1) 0.0 to 60 s (step 0.01 s)
Remote trip	
Note	Tripping of the remote end circuit-breaker for units with pilot-wire monitoring only
Setting ranges Prolongation time for transmission to remote station Delay time for reception from the remote station Prolongation time for reception from the remote station	 0 to 60 s (step 0.01 s) 0 to 60 s (step 0.01 s) 0 to 60 s (step 0.01 s)
Tolerances Delay time/release delay	 1 % and 10 ms respectively
Inherent delay Transmission time without delay	 Approx. 80 ms
Lockout function	
Lockout seal-in of trip command	For differential protection and remote trip until reset
Lockout reset	By means of binary input and/or local operator panel/DIGSI

Additional functions	
Operational measured values Operational currents Measurement range Tolerance (I_1)	 I_1, I_2, I_{Diff}, $I_{restraint}$ 0 to 240 % I_N 3 % of rated value or of measured value
Fault event recording	Storage of the events relating to the last 8 faults
Time-tagging Resolution for operational events for fault events	 1 s 1 ms
Fault recording (max. 8 faults) Storage time (from response or trip command)	 Total of 5 s max., pre-trigger and post-fault time settable
Maximum length per recording T_{max} Pre-trigger time T_{pre} Post-fault time T_{post}	0.30 to 5.00 s (step 0.01 s) 0.05 to 0.50 s (step 0.01 s) 0.05 to 0.50 s (step 0.01 s)
Time resolution at 50 Hz Time resolution at 60 Hz	1 instantaneous value per 1.66 ms 1 instantaneous value per 1.38 ms
Circuit-breaker test	Using test circuit

Technical data

4AM4930 summation current transformer

Power consumption in the circuit with standard connection L1-L3-E (Fig. 7/6) referred to the through-flowing rated current (7SD600 unit in operation).

		in phase (approx. VA)		
I_N		L1	L2	L3
1 A	Single-phase	2.2	1.3	1.7
	Symmetrical three-phase	0.6	0.2	0.35
5 A	Single-phase	3.5	1.5	2.2
	Symmetrical three-phase	0.7	0.2	0.5

	Connections	4AM4930-7DB	4AM4930-6DB
CT rated current		$I_N = 1$ A	$I_N = 5$ A
Number of turns			
Primary windings	A to B	5	1
	C to D	10	2
	E to F	15	3
	G to H	30	6
	I to K	30	6
	K to L	30	6
	L to M	60	12
Secondary windings	Y to Z	1736	1736
Thermal rating			
Continuous current in Amperes	A to B	4.5	20
	C to D	4.5	20
	E to F	4.5	20
	G to H	4.5	20
	I to K	1.2	6.5
	K to L	1.2	6.5
	L to M	1.2	6.5
	Y to Z	0.2	0.2
Secondary rated current with standard connection (see Fig. 7/6) and symmetrical 3-phase current	Y to Z	20 mA	20 mA

Requirements for the current transformers (CT)

$$K'_{ssc} \geq \frac{I_{scc\,max\,(ext.\,fault)}}{I_{pn}}$$

and:

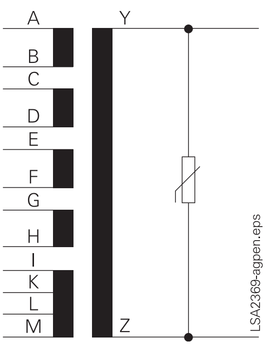
$$\frac{3}{4} \leq \frac{(K'_{ssc} \cdot I_{pn})_{end\,1}}{(K'_{ssc} \cdot I_{pn})_{end\,2}} \leq \frac{4}{3}$$

K'_{ssc1} = effective symmetrical short-circuit current factor end 1

K'_{ssc2} = effective symmetrical short-circuit current factor end 2

$I_{scc\,max}$ = maximum symmetrical short-circuit current

I_{pn} = CT rated primary current



CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Selection and ordering data

Description	Order No.
7SD60 numerical pilot-wire current comparison protection relay	*7SD600□-□□A□0-□DA0*
Rated current; rated frequency	
20 mA, 50/60 Hz; without external summation current transformer	*0*
1 A, 50/60 Hz; with external summation CT 4AM4930-7DB00-0AN2	*1*
5 A, 50/60 Hz; with external summation CT 4AM4930-6DB00-0AN2	*5*
Rated auxiliary voltage	
24, 48 V DC	*2*
60, 110, 125 V DC	*4*
220, 250 V DC, 115 V AC, 50/60 Hz	*5*
Unit design	
For panel surface mounting with terminals at the side	*B*
with terminals on top and bottom	*D*
For panel flush mounting or cubicle mounting	*E*
Operating language	
English – alternatively either German or Spanish can be selected	*0*
Scope of functions	
Differential protection	*0*
Differential protection, inrush restraint	*1*
Differential protection, pilot-wire monitoring, remote trip	*2*
Differential protection, pilot-wire monitoring, remote trip, inrush restraint	*3*

Accessories

DIGSI 4

Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000 or XP Professional) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)

Description	Order No.
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000 and XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*

Accessories

Description	Order No.
*Converter R232 (V.24) - RS485**	
With connecting cable 1 m, PC adapter, with plug-in power supply unit 230 V AC	7XV5700-0☐☐00[1)]
With plug-in power supply unit 110 V AC	7XV5700-1☐☐00[1)]
Converter RS485-FO	
Rated auxiliary voltage 24 to 250 V DC and 250 V AC	
Single optical interface	7XV5650-0BA00
Double optical interface (cascadable)	7XV5651-0BA00
Summation current transformer	
1 A, 50/60 Hz, for 7SD600	4AM4930-7DB00-0AN2
5 A, 50/60 Hz, for 7SD600	4AM4930-6DB00-0AN2
Isolating transformer	
Up to 20 kV	7XR9513
Up to 5 kV	7XR9515
Manual for 7SD60	
English	E50417-G1176-C069-A3

7

1) Possible versions see part 14.

* RS485 bus system up to 115 kbaud
RS485 bus cable and adaptor
7XV5103-☐AA☐☐; see part 14.

Connection diagram

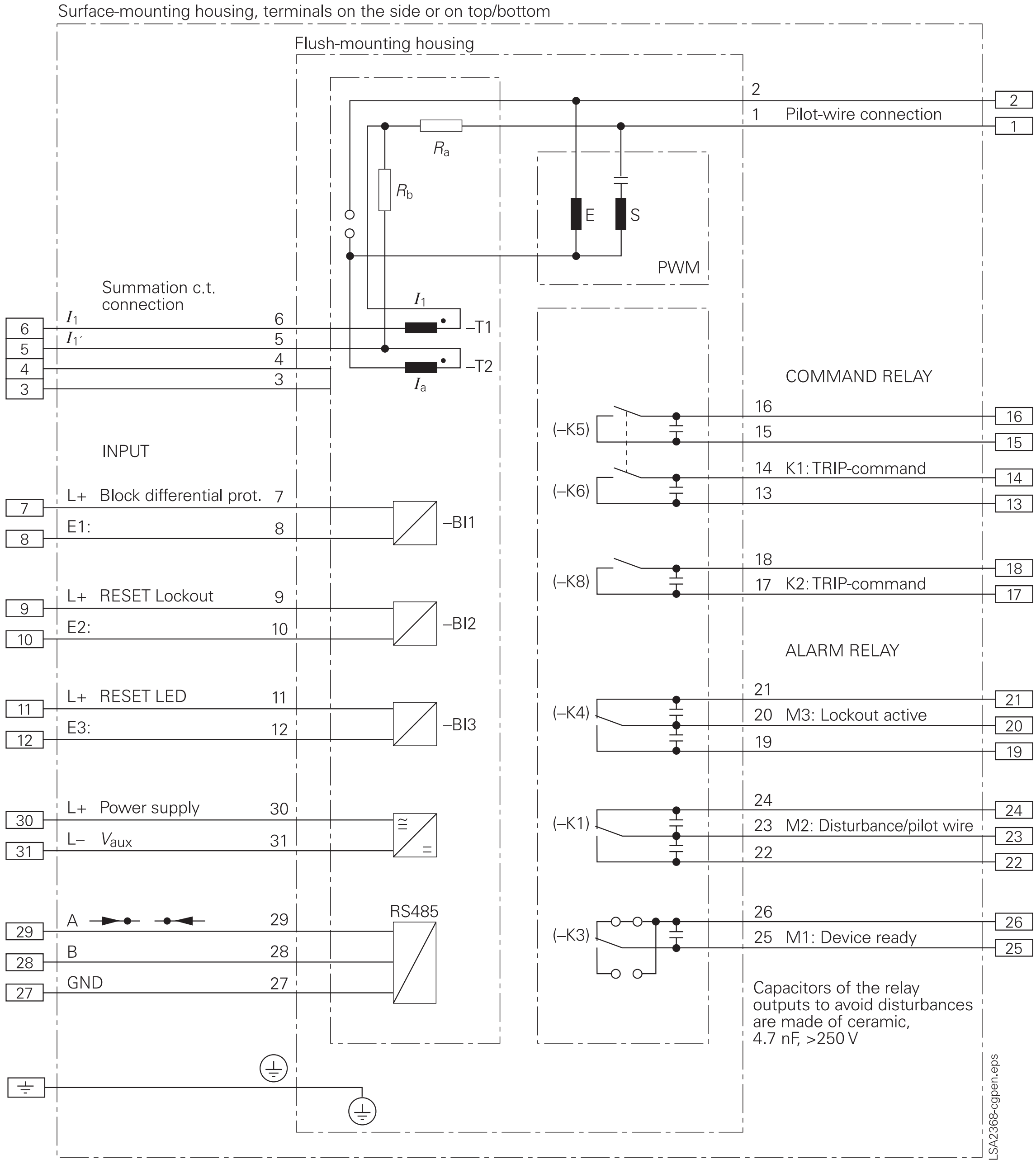


Fig. 7/9 Connection diagram of the 7SD60 current differential protection

SIPROTEC 4 7SD61
Differential Protection Relay for Two Line Ends

LSP2247-afpen.tif

Fig. 7/10
SIPROTEC 4 7SD61
differential protection relay

Description

The 7SD610 relay is a differential protection relay suitable for all types of applications and incorporating all those functions required for differential protection of lines, cables, transformers and busbars. Transformers and compensation coils within the differential protection zone are protected by means of integrated functions, which were previously to be found only in transformer differential protection. It is also well-suited for complex applications such as series and parallel compensation of lines and cables.

It is designed to provide protection for all voltage levels and types of networks; two line ends may lie within the protection zone. The relay features very high-speed and phase-selective short-circuit measurement. The unit is thus suitable for single-phase and three-phase fault clearance.

Digital data communication for differential current measurement is effected via fiber-optic cables, networks or pilot wires connections, so that the line ends can be quite far apart. The serial protection data interface (R2R interface) of the relay can flexibly be adapted to the requirements of all existing communication media. If the communication method is changed, flexible retrofitting of communication modules to the existing configuration is possible. Thanks to special product characteristics, the relay is particularly suitable for use in conjunction with digital communication networks. The units measure the delay time in the communication network and adaptively match their measurements accordingly. The units can be operated through pilot wires or twisted telephone pairs at typical distances of 15 km by means of a special converter.

Function overview

Application

- Differential protection for universal use with power lines and cables on all voltage levels (87L)
- Two line ends capability
- Suitable for transformers in protected zones (87T)
- Well-suited for serial compensated lines

Protection functions

- Differential protection with phase-segregated measurement
- Sensitive measuring stage for high-resistance faults
- Phase overcurrent protection (50, 50N, 51, 51N)
- Phase-selective intertripping (85)
- Overload protection (49)
- Auto-reclosure single/three-pole (79)

Control functions

- Command and inputs for ctrl. of CB and disconnectors (isolators)

Monitoring functions

- Self-supervision of the relay
- Trip circuit supervision (74TC)
- 8 oscillographic fault records
- CT-secondary current supervision
- Event logging / fault logging
- Switching statistics

Front design

- User-friendly local operation
- PC front port for convenient relay setting
- Function keys and 8 LEDs f. local alarm

Communication interfaces

- 1 serial protection data (R2R) interface
- System interface
  - IEC 60870-5-103 protocol
  - PROFIBUS-DP and DNP 3.0
- Service / modem interface (rear)
- Time synchronization via IRIG-B, DCF77 or system interface

Features

- Browser-based commissioning tool
- Tripping time 15 ms
- Direct connection to digital communication networks

7

Application

The 7SD610 relay is a differential protection relay suitable for all types of applications and incorporating all those functions required for differential protection of lines, cables and transformers.
Transformers and compensation coils within the differential protection zone are protected by means of integrated functions, which were previously to be found only in transformer differential protection. It is also well-suited for complex applications such as series and parallel compensation of lines and cables.

It is designed to provide protection for all voltage levels and types of networks; two line ends may lie within the protection zone. The relay features very high-speed and phase-selective short-circuit measurement. The unit is thus suitable for single and three-phase fault clearance. The necessary restraint current for secure operation is calculated from the current transformer data by the differential protection unit itself.

Digital data communication for differential current measurement is effected via fiber-optic cables or digital communication and pilot wires, so that the line ends can be quite far apart. Thanks to special product characteristics, the relay is particularly suitable for use in conjunction with digital communication networks.

The units measure the delay time in the communication network and adaptively match their measurements accordingly. The units can be operated through pilot wires or twisted telephone pairs at typical distances of 15 km by means of special converters.

The serial communication interfaces for data transmission between the ends are replaceable by virtue of plug-in modules and can easily be adapted to multi-mode and mono-mode fiber-optic cables and to leased lines or switched lines within the communication networks. Extremely fast, selective and sensitive protection of two-end lines can now be provided by means of these relays.

ANSI	IEC	
87L		ΔI for lines/cables
87T		ΔI for lines / cables with transformers
85		Phase-selective intertrip, remote trip
86		Lockout function
50 50N 51 51N		Three-stage overcurrent protection
50HS		Instantaneous high-current tripping (switch-onto-fault)
79		Single or three-pole auto-reclosure with new adaptive technology
49		Overload protection
50BF		Breaker failure protection
74TC		Trip circuit supervision

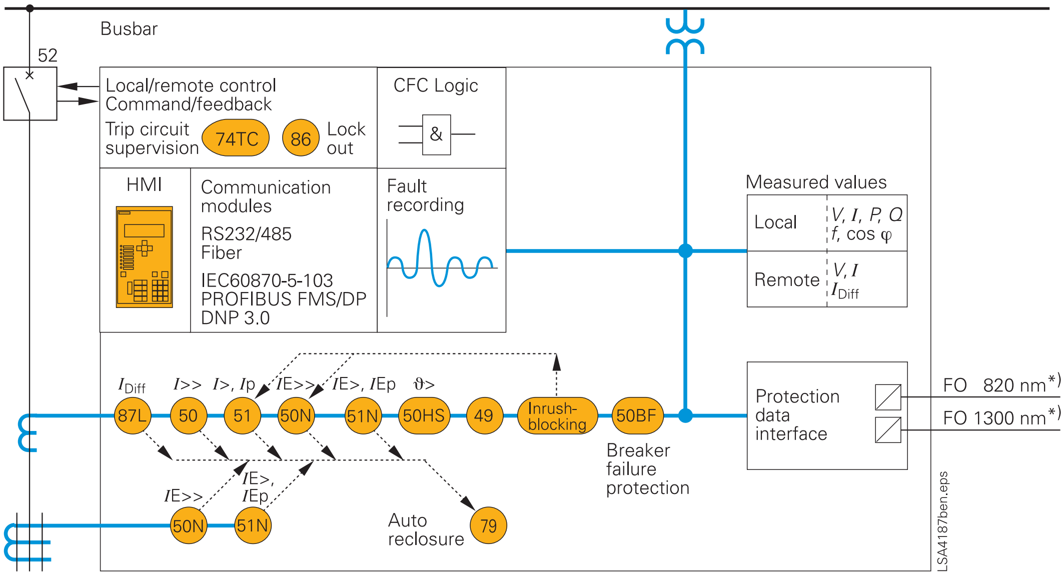


Fig. 7/11

*) Option

Application

Typical applications employing fiber-optic cables or communication networks

Four applications are shown in Fig. 7/12. The 7SD610 differential protection relay is connected to the current transformers and to the voltage transformers at one end of the cable, although only the currents are required for the differential protection function. The voltage connection improves, among other things, the frequency measurement and allows the measured values and the fault records to be extended. Direct connection to the other units is effected via mono-mode fiber-optic cables and is thus immune to interference.

Four different modules are available. In the case of direct connection via fiber-optic cables, data communication is effected at 512 kbit/s and the command time of the protection unit is reduced to 15 ms. Parallel compensation (for the load currents) is provided within the protection zone of the cable. By means of the integrated inrush restraint, the differential protection relay can tolerate the surge on switching-on of the cable and the compensation reactors, and thus allows sensitive settings to be used under load conditions.

7SD610 offers many features to reliably and safely handle data exchange via communication networks.

Depending on the bandwidth available in the communication system, 64, 128 or 512 kbit/s can be selected for the X21 (RS422) interface, whereas the G703.1 interface works with 64 kbits/s.

The connection to the communication converter is effected via a cost-effective 820 nm interface with multi-mode fiber. This communication converter converts the optical input to electrical signals.

The third example shows the relays being connected via a twisted pilot pair. Data exchange and transmission is effected via pilot wires of an approximate length of 8 km.
Here a transformer is in the protected zone. In this application, 7SD610 is set like a transformer differential relay. Vector group matching and inrush restraint is provided by the relay.

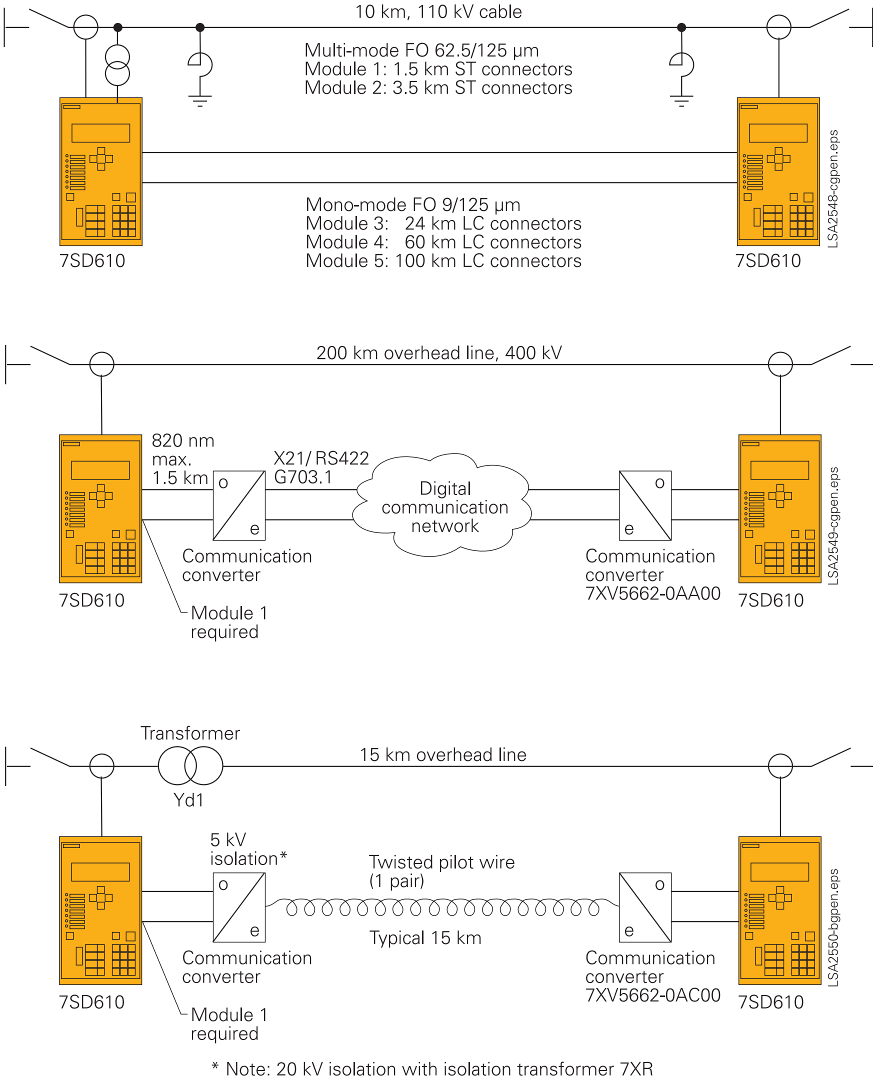


Fig. 7/12
Typical applications

Construction

The 7SD610 is available in a housing width of 1/3, referred to a 19” module frame system. The height is 243 mm.

All cables can be connected with or without cable ring lugs. Plug-in terminals are available as an option, it is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located on the same sides of the housing. For dimensions, please refer to “Dimension drawings”.

Fig. 7/13

7

Protection functions

Differential protection (ANSI 87L, 87T)

The differential protection function has the following features:

- Measurements are performed separately for each phase; thus the trip sensitivity is independent of the fault type.
- An adaptive measurement method with high sensitivity for differential fault currents below the rated current offers the detection of highly resistive faults. This trip element uses special filters, which offer high security even with high level DC components in the short-circuit current. The trip time of this stage is about 35 ms, the pickup value is about 10 % of the rated current.
- A high-set differential trip stage which clears differential fault currents higher than the rated current within 15 ms offers fast tripping time and high-speed fault clearance time. A high-speed charging comparison method is employed for this function.
- When a long line or cable is switched on at one end, transient peaks of the charge current load the line. To avoid a higher setting of the sensitive differential trip stage, this setpoint may be increased for a settable time. Under normal operating conditions, the relay is switched automatically to the sensitive setting.
- A new feature of the unit is parameterization of the current transformer data. The unit automatically calculates the necessary restraint current by means of the previously entered current transformer error. The unit thus adaptively matches the working point on the tripping characteristic so that it is no longer necessary for the user to enter characteristic settings.
- Different current-transformer ratios may be employed at the ends of the line. A mismatch of 1:8 is permissible. The tripping values of the unit are referred to a rated operating current previously entered by the user.
- Differential protection tripping can be combined with overcurrent pickup. In this case, pickup of the protection relay is initiated only on simultaneous presence of differential current and overcurrent.
- Easy to set tripping characteristic. Because the relay calculates its restraint current, only the setpoint I_{Diff}> and I_{Diff}>> must be set.
- Differential and restraint current are monitored continuously during normal operation and are displayed as operational measured values.
- High stability during external faults even with different current transformers saturation level. For an external fault, only 5 ms of saturation-free time are necessary to guarantee the reliability of the differential protection.
- Single-phase short-circuits within the protection zone can be cleared using a time delay, whereas multi-phase faults are cleared instantaneously. Because of this function, the unit is optimally suited for applications in inductively compensated networks, where differential current can occur as a result of charge transfer phenomena on occurrence of a single-phase earth fault within the protection zone, thus resulting in undesired tripping by the differential protection relay. Undesired tripping of the differential protection can be suppressed by making use of the provision for introduction of a time delay on occurrence of single-phase faults.
- With transformers or compensation coils in the protection zone, the sensitive response threshold I_{Diff}> can be blocked by an inrush detection function. Like in transformer differential protection, it works with the second harmonic of the measured current compared with the fundamental component. Blocking is cancelled when an adjustable threshold value of the short-circuit current is reached, so that very high current faults are switched off instantaneously.
- In the case of transformers within the protection zone, vector group adaptation and matching of different current transformer ratios is carried out within the unit. The interference zero current, which flows through the earthed winding, is eliminated from the differential current measurement. The 7SD610 thus behaves like a transformer differential relay whose ends, however, can be quite far apart.

Protection functions

Characteristics of differential protection communciation through the remote relay interfaces

The 7SD610 is ideally adapted for application in communication networks.

The data required for measurement of differential currents and numerous other variables are exchanged between the protection units in the form of synchronous serial telegrams employing the full duplex mode. The telegrams are secured using 32-bit checksums so that transmission errors in a communication network are detected immediately. Moreover, each telegram carries a time stamp accurate to a microsecond, thus allowing measurement and monitoring of the continuous transmission delay times.

- Data communication is immune to electromagnetic interference, since fiber-optic cables are employed in the critical region.
- Monitoring of each individual incoming telegram and of overall communication between the units, no need of supplementary equipment. The check sum (correctness of the telegram contents), the address of the neighboring unit and the transmission delay time of the telegram are monitored.
- Unambiguous identification of each unit is ensured by assignment of a settable communication address within a differential protection topology. Only those units mutually known to each other can cooperate. Incorrect interconnection of the communication links results in blocking of the protection system.
- Detection of telegrams, which are reflected back to the transmitting unit within the communication network.
- Detection of path switching in a communication network. Automatic restraint of the protection function until measurement of the parameters of the new communication link has been completed.
- Continuous measurement of the transmission delay time to the remote line end. Taking into account the delay time in differential current measurement and compensation thereof, including monitoring of a settable maximum permissible delay time of 30 ms.
- Generation of alarm signals on disturbed communication links. Statistical values for the percentage availability of the communication links per minute and per hour are available as operational measured values.

Phase-selective intertrip and remote trip/indications

Normally the differential current is calculated for each line end nearly at the same time. This leads to fast and uniform tripping times. Under weak infeed conditions, especially when the differential function is combined with an overcurrent pickup, a phase-selective intertrip offers a tripping of both line ends.

- 7SD610 has 4 intertrip signals which are transmitted in high-speed mode (20 ms) to the other terminals. These intertrip signals can also be initiated and transmitted by an external relay via binary inputs. In cases where these signals are not employed for breaker intertripping, other alternative information can be rapidly transmitted to the remote end of the line.
- In addition, four high-speed remote commands are available, which can be introduced either via a binary input or by means of an internal event and then rapidly communicated to the other end.
- Provided that the circuit-breaker auxiliary contacts are wired to binary inputs at the line ends, the switching status of the circuit-breakers is indicated and evaluated at the remote ends of the line. Otherwise the switching status is derived from the measured current.

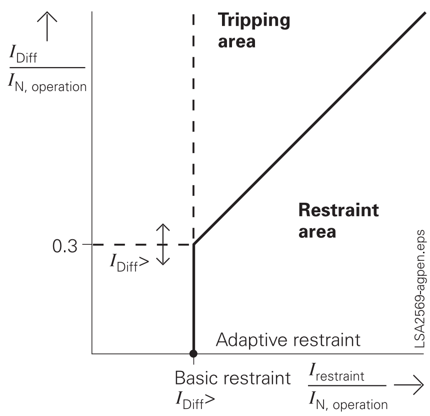


Fig. 7/14
Tripping characteristic

Possible modes of operation of the differential protection section

Special modes of operation such as the "Commissioning mode" and "Test operation" are advantageous for commissioning and servicing the units.

- In general, an alarm indication is generated on interruption of the communication links and an attempt is made to re-establish the communication link. The units operate in the emergency or backup mode, provided that these have been parameterized.
- The complete configuration can also be used in a testing mode. The local end is in an operating mode, which, for example, allows the pickup values to be tested. The current values received from the remote end of the line are set to zero, so as to achieve defined test conditions. The remote-end unit ignores the differential currents, which occur as a result of testing, and blocks differential protection and breaker intertripping. It may optionally operate in the backup protection mode.
- Differential protection is activated in the commissioning mode. However, test currents injected at one end of the line and which generate a differential current do not lead to output of a TRIP command by the differential protection or to breaker intertripping. All those indications that would actually occur in conjunction with a genuine short-circuit are generated and displayed. TRIP commands can be issued by the backup protection.

Protection functions

Thermal overload protection (ANSI 49)

A built-in overload protection with a current and thermal alarm stage is provided for thermal protection of cables and transformers.

The trip time characteristics are exponential functions according to IEC 60255-8. The preload is considered in the trip times for overloads.

An adjustable alarm stage can initiate an alarm before tripping is initiated.

Overcurrent protection (ANSI 50, 50N, 51, 51N)

The 7SD610 provides a three-stage overcurrent protection. Two definite-time stages and one inverse-time stage (IDMT) are available, separately for phase currents and for the earth current. Two operating modes are selectable. The function can run in parallel to the differential protection or only for backup during interruption of the protection communication. Two stages e.g. can run in backup mode, whereas the third stage is configured for emergency operation.

The following ANSI/IEC inverse-time characteristics are available:

- Inverse
- Short inverse
- Long inverse
- Moderately inverse
- Very inverse
- Extremely inverse
- Definite inverse

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. On large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast three-pole tripping.

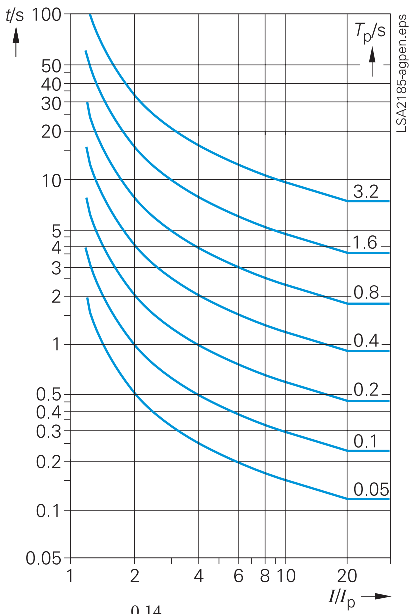
Circuit-breaker closure onto a faulty line is also possible provided that the circuit-breaker auxiliary contacts of the remote end are connected and monitored. If an overcurrent arises on closing of the circuit-breaker at one end of a line (while the other end is energized) the measured current can only be due to a short-circuit. In this case, the energizing line end is tripped instantaneously.

In the case of circuit-breaker closure, the auto-reclosure is blocked at both ends of the line to prevent a further unsuccessful closure onto a short-circuit.
If circuit-breaker intertripping to the remote end is activated, intertripping is also blocked.

Auto-reclosure (ANSI 79)

The 7SD610 relay is equipped with an auto-reclosure function (option). For 1-phase or for multi-phase faults, different dead times can be set. The function includes several operating modes:

- 3-pole auto-reclosure (AR) for all types of faults.
- 1-pole auto-reclosure for 1-phase faults, no AR for multi-phase faults.
- 1-pole AR for 1-phase faults and for 2-phase faults without earth connection.
- 1-pole AR for 1-phase and 3-pole AR for multi-phase faults.
- Multiple-shot AR. Up to 8 ARs are possible.
- Interaction with an external protection relay for AR via binary inputs and binary outputs.



$$t = \frac{0{,}14}{(I/I_p)^{0{,}02} - 1} T_p$$

Fig. 7/15 Inverse

- Adaptive auto-reclosure: Both breakers open after the fault in the protection zone has been detected. The breaker is switched on by only one relay. If the fault has disappeared, the other line end is switched on via communication links. If not, the line end makes a final trip.
- Interrogation of synchro-check protection before auto-reclosure occurs. This issues the release signal for auto-reclosure to the unit via a binary input.
- Monitoring of the circuit-breaker auxiliary contacts and c.b.-ready status.
- Voltage check for discrimination between successful and non-successful reclose attempts.

In addition to the above-mentioned operating modes, several other operating modes can be performed and configured according to user-specific requirements by means of the integrated programmable logic (CFC).

Protection functions

Breaker failure protection (ANSI 50BF)

The 7SD610 relay incorporates a two-stage breaker failure protection to detect the failure of tripping command execution, for example, due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command is generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

High-speed current monitoring and other monitoring functions

Numerous monitoring functions for hardware and software are implemented in the 7SD610 unit. The measuring circuits, analog-to-digital conversion and the supply voltages, memory and software execution (watch-dog function) are monitored.

An open circuit between the CTs and relay inputs under load may lead to tripping of a differential relay if the load current exceeds the differential setpoint. The 7SD610 provides fast bus wire supervision which immediately blocks all line ends if an open circuit is measured by a local relay. This avoids maloperation due to open circuit. Only the phase where the open circuit is detected is blocked. The other phases remain under differential operation.

Additional measurement supervision functions are:

- Symmetry of voltages and currents
- Summation of phase currents and comparison with the measured current at measuring input for the I_4-earth current transformer. If a significant difference is detected, the differential protection is blocked immediately, because this difference can only originate in a hardware fault of the unit's analog part.
- Phase-sequence supervision.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted. For each trip circuit, 1 or 2 binary inputs can be used.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only be issued after the lockout state has been reset.

Local measured values

The measured values are calculated from the measured current and voltage signals along with the power factor (cos φ), the frequency, the active and reactive power. Measured values are displayed as primary or secondary values.

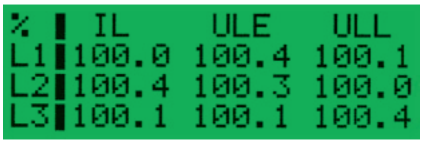
The relay uses a high-resolution AD converter and the analog inputs are factory calibrated, so a high accuracy is reached (under 0.5 % with rated current). The following values are available for measured value processing:

- Currents $3 \cdot I_{\text{phase}}$, $3\ I_0$, I_E
- Voltages $3 \cdot V_{\text{phase-earth}}$, $3 \cdot V_{\text{phase-phase}}$, $3V_0$, V_{en}
- Symmetrical components I_1, I_2, V_1, V_2 (positive and negative phase-sequence system)
- Active power P (Watt), Reactive power Q (Var), Apparent power S (VA)
- Power factor p.f. (= cos φ)
- Frequency f
- Differential and restraint current per phase

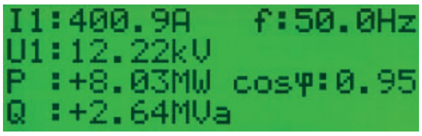
Limit values are calculated by means of the CFC. User-specific indications can be derived from these limit value indications like overload conditions or overvoltage.

Measured values at remote line ends

Every two seconds, the currents and voltages are freezed at the same time and transmitted via the communication link. Therefore, currents and voltages at the two line ends are always available with their amount and phases. This allows the whole configuration to be checked under load conditions (load current of 10 % is sufficient). In addition, the differential and restraint currents are also displayed. Important communication link measurements, such as delay time or as percentage availability per minute/hour are also available as measurements.
These measured values can be processed with the help of the CFC logic editor.

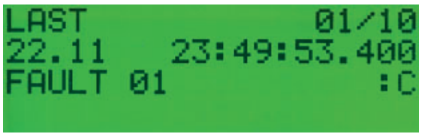


LSP2097-afpen.tif



LSP2064-afpen.tif

Operational measured values are clearly shown on the LCD display



LSP2066-afpen.tif

Some fault indications are shown automatically on the LCD display

1) Disc-emulation with inverse-time characteristic may be applied with ANSI characteristics.

7

Functions

Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user.

Furthermore, all currents and voltages and their phasors are available via communication link at the local relay and displayed in the relay, with DIGSI 4 or a special commissioning program running under a standard browser (Internet Explorer or Netscape Navigator).

Browser-based commissioning tool

The 7SD610 provides a commissioning and test program which runs under a standard Internet Browser (no other special software is required at the PC). Protection topology and comprehensive measurements from the local and remote terminal are shown. The breaker position of each line end is displayed, as well as the tripping characteristic of the relay.

It is possible to check the correct connection of the current transformers or the correct vector group of a power transformer. Stability can be checked by using the operating characteristic as well as the calculated differential and restraint values in the browser windows.

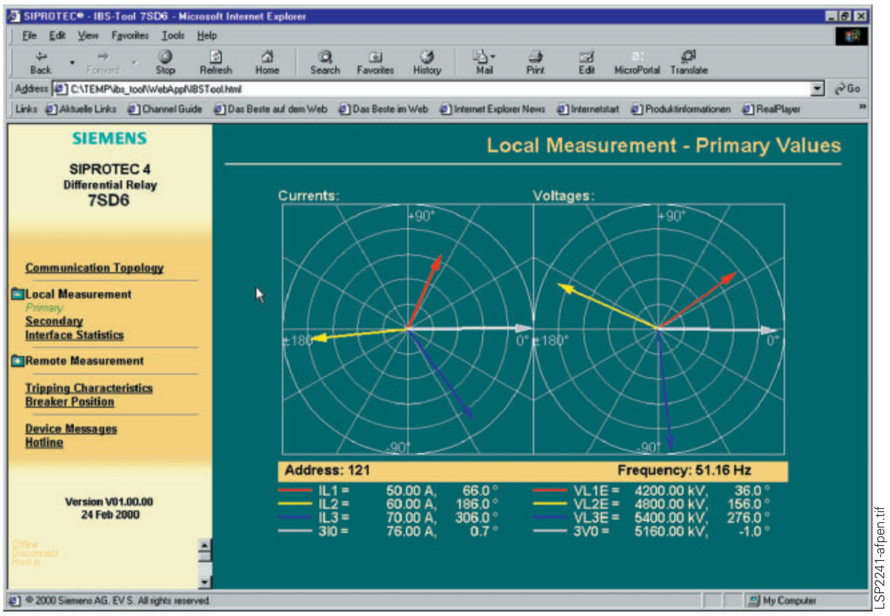


Fig. 7/16 Browser-aided commissioning

Functions

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Functions

With respect to communication, particular emphasis has been placed on high flexibility, data security and use of customary standards in the field of energy automation. The concept of the communication modules allows interchangeability on the one hand, and, on the other hand, is open for future standards (e.g. Ethernet).

Local PC interface

The PC interface provided on the front panel on the unit allows the parameters, status and fault event data to be rapidly accessed by means of the DIGSI 4 operating program. Use of this program is particularly advantageous during testing and commissioning.

Rear-mounted interfaces

The service and system communication interfaces are located at the rear of the unit. In addition, the 7SD610 is provided with a protection interface. The interface complement is variable and retrofitting is possible without any difficulty. These interfaces ensure that the requirements for different communication interfaces (electrical and optical) and protocols can be met.

The interfaces are designed for the following applications:

Service / modem interface

By means of the RS485 interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants.

In the case of the 7SD610, a PC with a standard browser can be connected to the service interface (refer to "Commissioning program").

System interface

This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7SD610, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to "Commissioning program"). The relays include a small Web server and sends its HTML pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 60870-5-103, PROFIBUS-DP, DNP 3.0, Ethernet[1], DIGSI, etc.) are required, such demands can be met.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

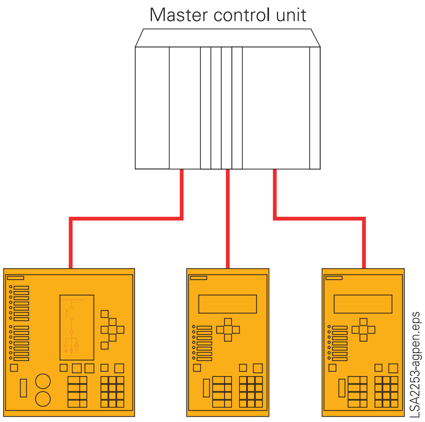


Fig. 7/17
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

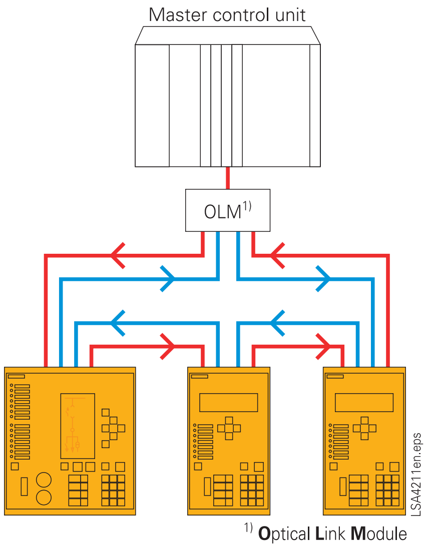


Fig. 7/18
Bus structure: Fiber-optic double ring circuit

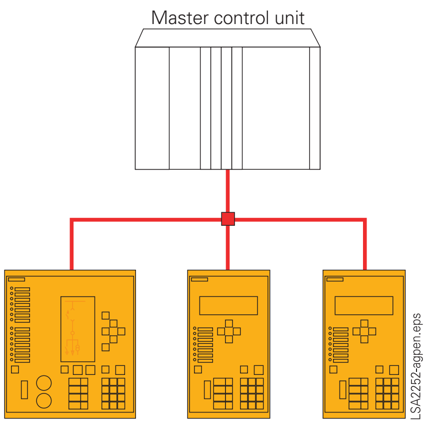


Fig. 7/19
Bus structure: RS485 copper conductor connection

1) In course of preparation

Communication

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area.
IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

Ethernet / IEC 61850 1)

Ethernet IEC 61850 application-specific profile for energy automation applications is currently in course of preparation.
As soon as standardization work has been completed, SIPROTEC 4 units will be upgraded to meet the requirements of the new standard. Retrofitting can be carried out simply by insertion of an Ethernet communication module.

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems.

Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the protection unit. Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

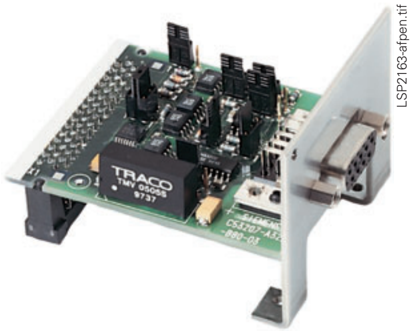


Fig. 7/20 RS232/RS485 electrical communication module

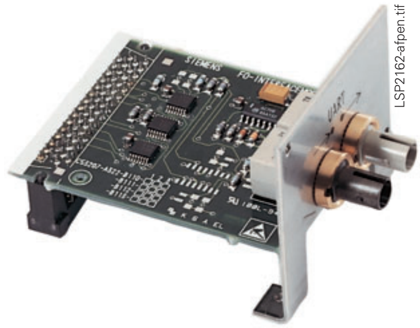


Fig. 7/21 Fiber-optic communication module

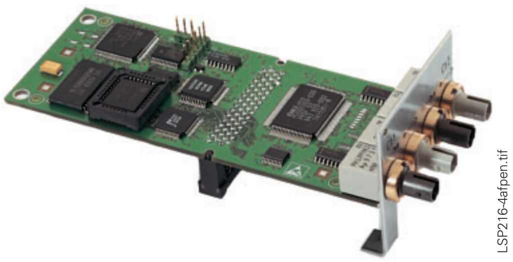


Fig. 7/22
Communication module, optical double-ring

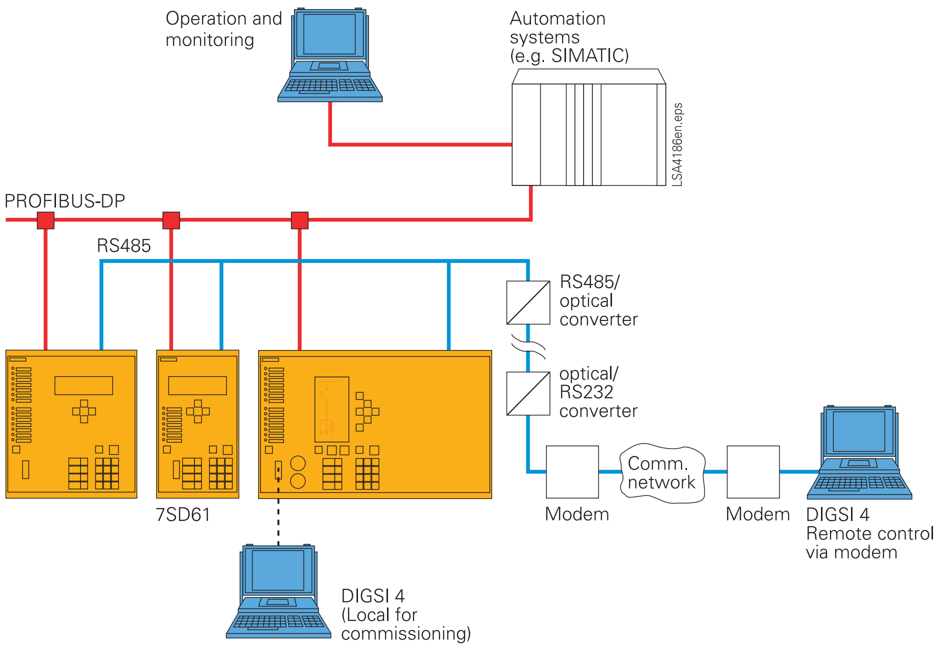


Fig. 7/23
System solution: Communications

1) In course of preparation

Communication

Serial protection data interface (R2R interface)

As an option, the 7SD610 provides one protection data interface for two line end applications.
In addition to the differential protection function, other protection functions can use this interface to increase selectivity and sensitivity as well as covering advanced applications.

- Interclose command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- 28 remote signals for fast transfer of binary signals
- Flexible utilization of the communication channels by means of the programmable CFC logic.

The protection data interface has different options to cover new and existing communication infrastructures

- FO5[1)], OMA1[2)] module:
  820 nm fiber-optical interface with clock recovery/ST connectors for direct connection with multi-mode FO cable up to 1.5 km for the connection to a communication converter.
- FO6[1)], OMA2[2)] module:
  820 nm fiber-optical interface/ST connectors for direct connection up to 3.5 km with multi-mode FO cable.

New fiber-optic interfaces, series FO1x

- FO17[1)]: For direct connection up to 24 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1)]: For direct connection up to 60 km[3)] 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1)]: For direct connection up to 100 km[3)] 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703.1 interface.

For operation via copper wire communication (pilot wires or twisted telephone pair), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. The connection via FO cable to the relay is interference-free. With SIPROTEC 4 and the communication converter for copper cables, a digital follow-up technique is available for two-wire or three-wire protection systems (typical 15 km) and all three-wire protection systems using existing copper communication links.

Furthermore, a communication converter is available, which enables the link to an ISDN connection via the S0-bus.

<u>Communication data:</u>

- Supported network interfaces G703.1 with 64 kbit/s; X21/RS422 with 64 or 128 or 512 kbit/s
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.

1) For flush-mounting housing.

2) For surface-mounting housing

3) For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Communication

Communication possibilities between relays

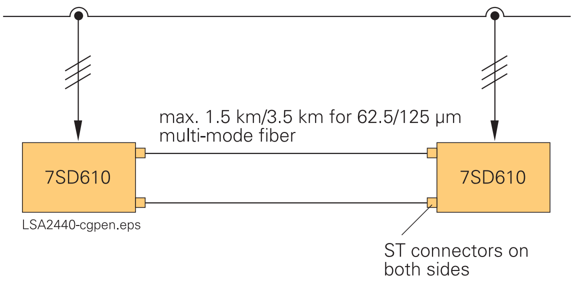


Fig. 7/24 Direct optical link up to 1.5 km / 3.5 km, 820 nm

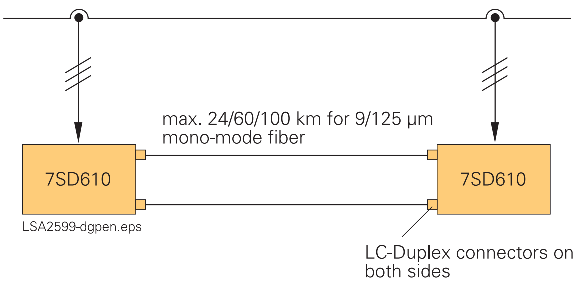


Fig. 7/25 Direct optical link up to 24 km / 60 km with 1300 nm or up to 100 km with 1550 nm

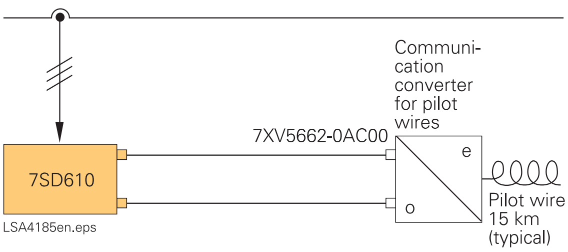


Fig. 7/26 Connection to a pilot wire

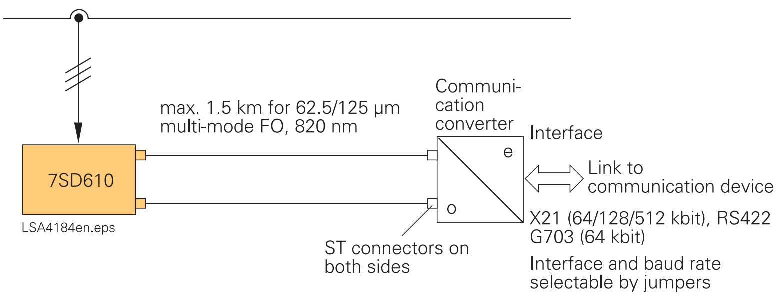


Fig. 7/27 Connection to a communication unit/digital telephone network/leased line

Typical connection

Connection to current and voltage transformers

A typical connection is to the phase CT. The residual current at the I_E input is formed by summation of the phase currents. This ensures optimum supervision functions for the current.

Optionally, voltages are measured by means of voltage transformers and are fed to the unit as a phase-to-earth voltage. The zero voltage is derived from the summation voltage by calculation performed in the unit.

As a matter of fact, the 7SD610 unit does not require any voltage transformers for operation of the differential protection.

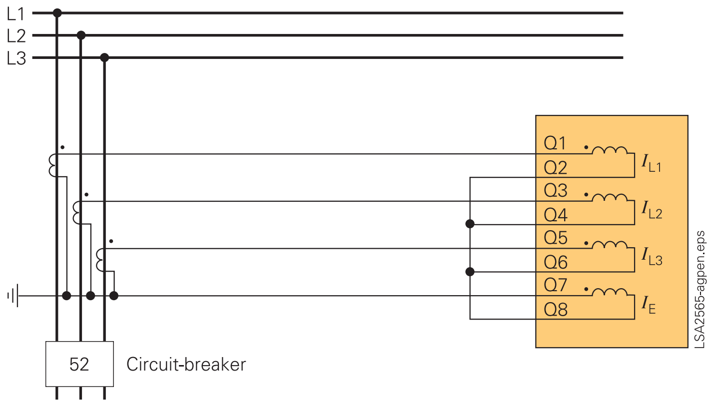


Fig. 7/28 Typical connection to current transformers

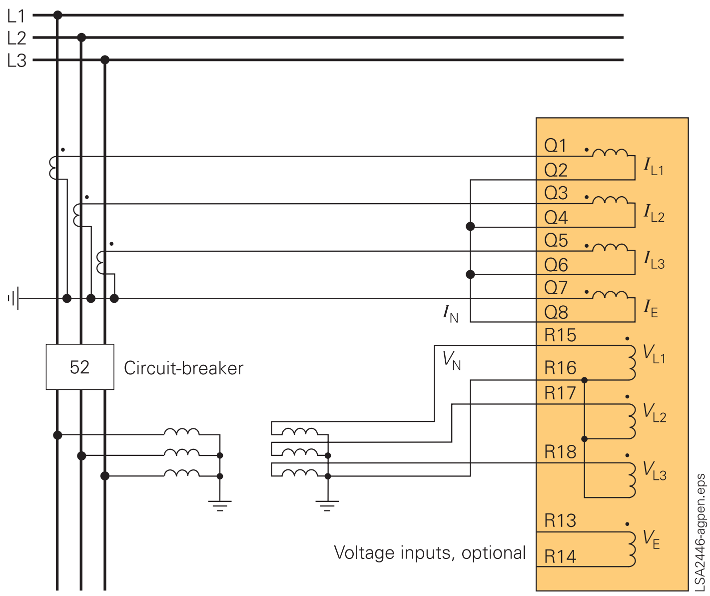


Fig. 7/29 Typical connection to current transformers with optional voltage inputs

Technical data

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_N	1 or 5 A (selectable)
Rated voltage V_N	80 to 125 V (selectable)
Power consumption in CT circuits with I_N = 1 A with I_N = 5 A in VT circuits	 Approx. 0.05 VA Approx. 0.3 VA Approx. 0.1 VA
Thermal overload capacity in CT circuits Dynamic (peak value)	I_N 100 A for 1 s 30 I_N for 10 s 4 I_N continuous 250 I_N (half sine)
In VT circuits for highly sensitive earth-fault protection in VT circuits	 300 A for 1 s 100 A for 10 s 15 A continuous 230 V per phase continuous
Auxiliary voltage	
Rated voltages Ranges are settable by means of jumpers	24 to 48 V DC 60 to 125 V DC[1)] 110 to 250 V DC[1)] and 115 V AC (50/60 Hz)[1)]
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption Under normal operating conditions During pickup with all inputs and outputs activated	 Approx. 8 W Approx. 18 W
Bridging time during failure of the auxiliary voltage V_{aux} ≥ 110 V	 ≥ 50 ms
Binary inputs	
Number	7 (marshallable)
Rated voltage range Pickup threshold	24 to 250 V, bipolar 17 or 73 V (selectable)
Functions are freely assignable	
Minimum pickup threshold Ranges are settable by means of jumpers for each binary input	 17 or 73 V DC, bipolar
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Output relay	
Command / indication relay	
Number	5 (marshallable) 1 alarm contact (not marshallable)
Switching capacity Make Break Break (with resistive load) Break (with L/R ≤ 50 ms)	 1000 W/VA 30 VA 40 W 25 W
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous

1) Ranges are settable by means of jumpers.

2) In course of preparation.

LEDs	
Number RUN (green) ERROR (red) LED (red), function can be assigned	 1 1 7
Unit design	
Housing 7XP20	For dimensions refer to dimension drawings, part 16
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing front rear for the terminals	 IP 51 IP 51 IP 50 IP 20 with terminal cover put on
Weight Flush-mounting housing 1/3 x 19" Surface-mounting housing 1/3 x 19"	 4 kg 6 kg

Serial interfaces	
Operating interface 1 for DIGSI 4 or browser (front of unit)	
Connection	Non-isolated, RS232, front panel, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud, setting as supplied: 38400 baud; parity 8E1
Time synchronization (rear of unit DCF77/IRIG-B signal format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminals with surface-mounting housing)
Voltage levels	5, 12 or 24 V (optional)
Service interface (op. interface 2) for DIGSI 4/modem/service/browser (rear of unit)	
Isolated RS232/RS485 Dielectric test Distance for RS232 Distance for RS485	9-pin subminiature connector (SUB-D) 500 V/50 Hz Max. 15 m Max. 1000 m
System interface (rear of unit)	
Refer to ordering code	IEC 61850 Ethernet[2)] IEC 60870-5-103 PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485 Baud rate Dielectric test Distance for RS232 Distance for RS485	9-pin subminiature connector (SUB-D) 4800 to 38400 baud 500 V/50 Hz Max. 15 m Max. 1000 m
For fiber-optic cable Optical wavelength Permissible attenuation Distance (spanned)	ST connector λ = 820 nm Max. 8 dB for 62.5/125 µm fiber Max. 1.5 km

Technical data

System interface, continued	
PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kbd; 100 m at 12 Mbd
PROFIBUS fiber-optic[2]	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[2]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for 62.5/125 µm fiber
Distance	500 kbit/s 1.6 km; 1500 kbit/s 530 m
Protection data interface (R2R interface)	
FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a comm. converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation: 8 dB
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation: 16 dB
New fiber-optic interfaces, series FO1	
FO17[1]: for direct connection up to 25 km[3], 1300 mm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 13 dB
FO18[1]: for direct connection up to 60 km[3], 1300 mm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 29 dB
FO19[1]: for direct connection up to 100 km[3], 1550 mm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation: 29 dB
Relay communication equipment	
External communication converter 7XV5662-0AA00 for communication networks	
External communication converter to interface between the relays, optical 820 nm interface and the X21/RS422/ G703.1 interface of a communication device	
X21/G703, RS422 selectable by jumpers. Baud rate selectable by jumpers	
Input: fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable to device side
Output: X21 (RS422) electrical interface on communication device	64/128/512 kbit (selectable by jumper) max. 800 m, 15-pin connector
G703.1 electrical interface on communication device	64 kbit/s, max. 800 m, screw-type terminal
External communication converter 7XV5662-0AC00 for pilot wires	
External communication converter to interface between relays, optical 820 nm interface and a pilot wire or twisted telephone pair.	
Typical distance	15 km
Fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable
Pilot wire	Screw-type terminal 5 kV isolated
Permissible time delay (duration of data transmission)	
Delay of telegrams due to transmission for one unit to the other. Delay is constantly measured and adjusted	Max. 30 ms per transmission path Permissible max. value can be selected

Electrical tests	
Specification	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 For further standards see "Individual functions"
Insulation tests	
Standards	IEC 60255-5
Voltage test (100 % test)	
All circuits except for auxiliary supply, binary inputs and communication interfaces	2.5 kV (r.m.s.), 50 / 60 Hz
Auxiliary voltage and binary inputs (100 % test)	3.5 kV DC
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 / 60 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for noise immunity; type tests	
Standards	IEC 60255-6, IEC 60255-22 (product standards) (type tests) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz

1) For flush-mounting housing.
2) For surface mounting housing.
3) For surface mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Technical data

Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω; 9 µF Differential (transversal) mode: 1 kV; 2 Ω; 18 µF
Measurement inputs, binary inputs, binary output relays	Common (longitudinal) mode: 2 kV; 42 Ω; 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second, duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 impulses per second; both polarities; duration 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillation IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; R_i = 200 Ω

***EMC tests for interference emission;** type tests*

Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

During operation

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis), 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis), 8 to 35 Hz: 1 *g* acceleration (horizontal axis), 8 to 35 Hz: 0.5 *g* acceleration (vertical axis), frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

During transport

Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration, Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress test

Temperatures

Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	–25 °C to +85 °C / –13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	–20 °C to +70 °C / –4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °C)	–5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	–25 °C to +55 °C / –13 °F to +131 °F
– Limiting temperature during transport	–25 °C to +70 °C / –13 °F to +158 °F

Humidity

Permissible humidity stress; It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; moisture condensation during operation is not permitted

Technical data

Functions

Differential protection (ANSI 87L, 87T)

Sensitive differential current trip stage $I_{Diff}>$	
Setting range	
$I_{Diff}> I_N$ secondary 1 A	0.1 to 20 A (steps 0.01 A)
secondary 5 A	0.5 to 100 A
Tripping time $I_{Diff}> 2 \times I_{Diff}>$ (setting value)	Typical 35 ms with FO cable
High current differential trip stage $I_{Diff}>>$	
Setting range	
$I_{Diff}>>$ secondary 1 A	0.8 to 100 A (steps 0.01 A)
secondary 5 A	4.0 to 50 A
Tripping time $I_{Diff}> 2 \times I_{Diff}>>$ (setting value)	Typical 16 ms with FO cable

Thermal overload protection (ANSI 49)

Setting range	
Factor k to IEC 60255.8	0.1 to 4 (steps 0.01)
Time constant τ	1 to 999.9 min (steps 0.1 min)
Thermal alarm stage $\Theta_{Alarm}/\Theta_{Trip}$	50 to 100 % referred to tripping temperature (steps 1 %)
Current-based alarm stage I_{alarm}	0.1 to 4 A(1A) / 0.5 to 5 A(5A) (steps 0.01 A)
Calculating mode for overtemperature	Θ_{max}, Θ_{mean}, Θ with I_{max}
Pickup time characteristic	$t = \tau \ln \frac{I^2 - I_{pre}^2}{I^2 - (k\,I_N)^2}$
Reset ratio	
Θ/Θ_{Alarm}	Approx. 0.99
Θ/Θ_{Trip}	Approx. 0.99
I / I_{Alarm}	Approx. 0.99
Tolerances	Class 10 % acc. to IEC 60255-8

Backup / emergency overcurrent protection (ANSI 50N, 51N)

Operating modes	Active only with loss of data connection or always active
Characteristic	2 definite-time stages / 1 inverse-time stage

Definite-time stage (ANSI 50, 50N)

Phase current pickup $I_{ph}>>$	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A) or deactivated
Earth current pickup $3I_0>>$	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) or deactivated
Phase current pickup $I_{ph}>$	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A)
Earth current pickup $3I_0>$	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A)
Time delay	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % setting value or 1 % of I_N
Delay times	± 1 % setting value or 10 ms
Operating time	Approx. 25 ms

Inverse-time stage (ANSI 51, 51N)

Phase current pickup I_p	0.1 to 4 A (1A) / 0.5 to 20 A (5A) (step 0.01 A)
Earth current pickup $3I_{0P}$	0.05 to 4 A (1A) / 0.25 - 20 A (5A) (step 0.01 A)
Tripping characteristics	
Tripping time characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long time inverse
Tripping time characteristics acc. to ANSI/IEEE (not for DE region, see selection and ordering data 10th position)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Time multiplier for IEC characteristics T	T_p = 0.05 to 3 s (step 0.01 s) or deactivated
Time multiplier for ANSI characteristics D	D_{IP} = 0.5 to 15 (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 I/I_p (ANSI: I/I_p = M)
Reset threshold	Approx. 1.05 x I/I_p (ANSI: I/I_p = M)
Tolerances	
Operating time for $2 \le I/I_p \le 20$	≤ 5 % of setpoint ± 15 ms

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Operating mode	Active only with connected auxiliary contacts
Characteristic	2 independent stages
Pickup current $I>>>$	0.1 to 15 A (1A) / 0.5 to 75 A (5A) (step 0.01 A) or deactivated
Pickup current $I>>>>$	1 to 25 A (1A) / 5 to 125 A (5A) (step 0.01 A) or deactivated
Reset ratio	Approx. 0.95
Tolerances	
Current starting	≤ 3 % of setting value or 1 % I_N

Auto-reclosure (ANSI 79)

Number of auto-reclosures	Up to 8
Operating modes with line voltage check	Only 1-pole; only 3-pole, 1 or 3-pole, adaptive AR Discrimination between successful and non-successful reclose attempts
Dead times $T_{1\text{-}ph}$, $T_{3\text{-}ph}$, T_{Seq}	0.01 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
CLOSE command duration	0.01 to 30 s (steps 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V

7

Technical data

Breaker failure protection (ANSI 50BF)	
Number of stages	2
Pickup of current element	0.05 to 20 A (1A) / 0.25 to 100 A (5A) (step 0.01 A)
Time delays $T1_{1phase}$, $T1_{3phase}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	CB synchronism monitoring
Reset time	10 ms, typical
Tolerances	
Current limit value	≤ 3 % of setting value or 1 % I_N
Time stages	1 % of setting value or 10 ms

Additional functions

Operational measured values	
Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; I_E; I_1; I_2
Tolerances	
10 to 50 % I_N	Typical ≤ 1 % of 50 % I_N
50 to 200 % I_N	Typical ≤ 1 % of measured value
Voltages	3 x $V_{Phase\text{-}Earth}$; 3 x $V_{Phase\text{-}Phase}$; $3V_0$, V_1, V_2
Tolerances	
10 to 50 % V_N	Typical ≤ 1 % of 50 % V_N
50 to 200 % V_N	Typical ≤ 1 % of measured value
Power with direction indication	P, Q, S
Tolerances	
P: for |cos φ| = 0.7 to 1 and V/V_N, I/I_N = 50 to 120 %	Typical ≤ 3 %
Q: for |sin φ| = 0.7 to 1 and V/V_N, I/I_N = 50 to 120 %	Typical ≤ 3 %
S: for V/V_N , I/I_N = 50 to 120 %	Typical ≤ 2 %
Frequency	f
Tolerance	≤ 20 mHz
Power factor	p.f. (cos φ)
Tolerance for |cos φ| = 0.7 to 1	Typical ≤ 3 %
Remote measurements	3 x $I_{Phase\text{-}Earth}$; 3 I_0, 3 x $V_{Phase\text{-}Earth}$; $3V_0$
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}
Fault record storage	
Measured analog channels	3 x I_{Phase}, $3I_0$, $3I_{Diff}$ 3 x V_{Phase}, $3V_0$, $3I_{Restraint}$
Max. number of available recordings	8, backed up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 10 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user

Further additional functions	
Measured value supervision	Current sum Current symmetry Voltage symmetry Bus wire supervision
Indications	
Operational indications	Buffer size 200
System disturbance indication	Storage of signals of the last 8 faults, buffer size 600
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operations Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE cycle per phase
Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Commissioning support	Operational measured values, CB test, status display of binary indication inputs, setting of output relays, generation of indications for testing serial interfaces, commissioning support via Web-browser, test mode, commissioning mode

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Order code
7SD61 differential protection relay for two line ends with 4-line display, housing width 1/3", 7 LEDs	7SD610□-□□□□□-□□□□	□□□
		see next page
Measurement input		
I_{phase} = 1 A[1)], I_E = 1 A (min. = 0.05 A)	1	
I_{phase} = 5 A[1)], I_E = 5 A (min. = 0.25 A)	5	
Rated auxiliary voltage (converters, binary inputs)		
24, 48 V DC, binary input threshold 17 V[3)]	2	
60, 125 V DC[2)], binary input threshold 17 V[3)]	4	
110, 250 V DC[2)], 115 V AC, binary input threshold 73 V[3)]	5	
Unit design/number of binary inputs and outputs		
For panel flush mounting, screw-type terminals 1/3 x 19"/7 BI, 6 BO	B	
For panel surface mounting, 2-tier terminals, 1/3 x 19"/7 BI, 6 BO	F	
For panel flush mounting, plug-in terminals, 1/3 x 19"/7 BI, 6 BO	K	
Region-specific default settings / language settings		
Region DE, language: German (selectable)	A	
Region World, language: English (GB) (selectable)	B	
Region US, language: English (USA) (selectable)	C	
Region FR, language: French (selectable)	D	
Region World, language: Spanish (selectable)	E	
System interfaces; functions and hardware		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm optical, double ring, ST connector[4)]	9	L 0 B
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, 820 nm optical, ST connector[4)]	9	L 0 H
DIGSI/modem interface rear of unit and protection data interface	9	M □□
DIGSI / modem interface (rear side of unit)		
DIGSI 4, electrical RS232		1
DIGSI 4, electrical RS485		2
Protection data interface (R2R interface)		
Optical 820 nm, 2 ST connectors, FO length up to 1.5 km for direct connection or via communication networks		A
Optical 820 nm, 2 ST connectors, FO length up to 3.5 km for direct connection via multi-mode fiber		B
Optical 1300 nm, LC-Duplex connector, FO cable length up to 24 km for direct connection via mono-mode FO cable		G
Optical 1300 nm, LC-Duplex connector, FO cable length up to 60 km for direct connection via mono-mode FO cable		H
Optical 1550 nm, LC-Duplex connector, FO cable length up to 100 km for direct connection via mono-mode FO cable		J

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected in two stages by means of jumpers.

4) For surface-mounting housing applications, please select option A (820 nm, 1.5 km) together with an external repeater (see "Accessories" for Order No.).

Selection and ordering data

Description	Order No.
7SD61 differential protection relay for two line ends with 4-line display, housing width 1/3″, 7 LEDs	*7SD610□-□□□□□-□□□□*
Functions 1	
Tripping only 3-pole, without auto-reclosure	0
Tripping only 3-pole, with auto-reclosure	1
Tripping 1 and 3-pole, without auto-reclosure	2
Tripping 1 and 3-pole, with auto-reclosure	3
Backup protection function	
With emergency/backup overcurrent-time protection	B
With emergency/backup overcurrent-time protection, with breaker failure protection	C
Additional functions 1	
Without additional functions	A
With transformer extensions (transformer in protection zone)	E
With 4 remote commands	J
With 4 remote commands/transformer extensions (transformer in protection zone)	N
Additional functions 2	
Without additional functions	0
With external GPS synchronization of the differential protection	1

7

Accessories

Description	Order No.
Opto-electric communication converter (connection to communication network)	
Converter to interface to X21 or G703.1 or RS422 synchronous communication interfaces. Connection via FO cable for 62.5 / 125 µm or 50 / 120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via X21/RS422 or G703.1 interface	7XV5662-0AA00
Opto-electric communication converter (connection to pilot wire)	
Converter to interface to a pilot wire or twisted telephone pair (typical 15 km length) Connection via FO cable for 62.5/125 µm or 50 / 120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector; max. distance 1.5 km, screw-type terminals to pilot wire	7XV5662-0AC00
Additional interface modules	
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km	C53207-A351-D651-1
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
Further modules	
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	C53207-A351-D655-1
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A351-D656-1
Protection data interface mod. opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A351-D657-1
Optical repeaters	
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	7XV5461-0BG00
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00
Time synchronizing unit with GPS output	
GPS 1 sec pulse and time telegram IRIG B/DCF 77	7XV5664-0AA00
Isolation transformer (20 kV) for pilot wire communication	7XR9516
Voltage transformer miniature circuit-breaker	
Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000/XP Professional) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional Complete version: DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000/XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
Manual for 7SD61 English	C53000-G1176-C145-1

Fig. 7/30 Mounting rail for 19" rack

Fig. 7/31
2-pin connector

Fig. 7/32
3-pin connector

Fig. 7/33
Short-circuit link
for current contacts

Fig. 7/34
Short-circuit link
for voltage contacts/
indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	C73334-A1-C35-1	1	Siemens	7/33
	3-pin	C73334-A1-C36-1	1	Siemens	7/34
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP [1)]	
		0-827396-1	1	AMP [1)]	
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP [1)]	
		0-827397-1	1	AMP [1)]	
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP [1)]	
		0-163084-2	1	AMP [1)]	
Crimping tool	For Type III+	0-539635-1	1	AMP [1)]	
	and matching female	0-539668-2		AMP [1)]	
	For CI2	0-734372-1	1	AMP [1)]	
	and matching female	1-734387-1		AMP [1)]	
19" mounting rail		C73165-A63-D200-1	1	Siemens	7/32
Short-circuit links	For current terminals	C73334-A1-C33-1	1	Siemens	7/35
	For other terminals	C73334-A1-C34-1	1	Siemens	7/36
Safety cover for terminals	Large	C73334-A1-C31-1	1	Siemens	
	Small	C73334-A1-C32-1	1	Siemens	

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

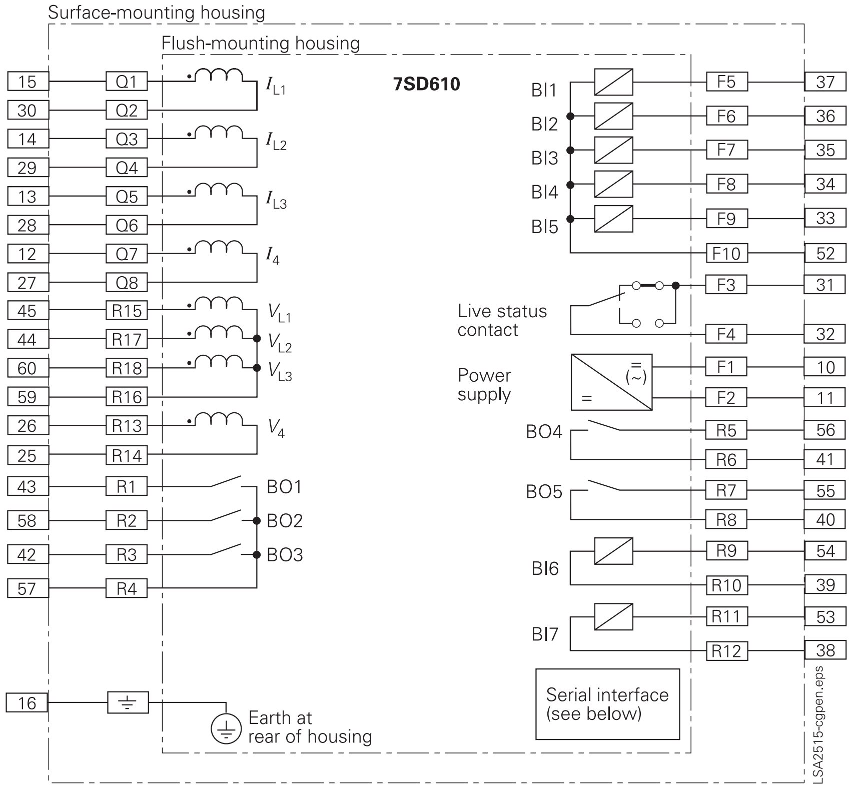


Fig. 7/35
Connection diagram

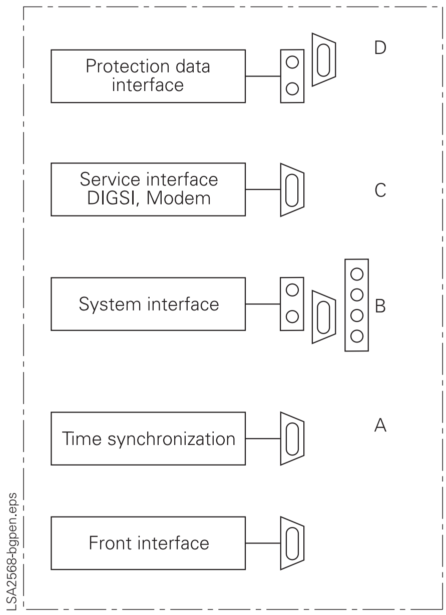


Fig. 7/36
Serial interfaces

SIPROTEC 4 7SD5
Multi-End Differential and Distance Protection in One Relay

Fig. 7/37
SIPROTEC 4
7SD5 differential protection relay

Description

The 7SD5 relay provides full scheme differential protection and incorporates all functions usually required for the protection of power lines. It is designed for all power and distribution levels and protects lines with two up to six line ends. The relay is designed to provide high-speed and phase-selective fault clearance. The relay uses fiber-optic cables or digital communication networks to exchange telegrams and includes special features for the use in multiplexed communication networks. Also pilot wires or ISDN connections can be used with an external converter. This contributes toward improved reliability and availability of the electrical power system.

The relay is suitable for single and three-phase tripping applications for two up to six line ends. Also, transformers and compensation coils within the differential protection zone are protected as are serial and parallel-compensated lines and cables. The relays may be employed with any type of system earthing.
The relay also provides a full-scheme and non-switched distance protection as an optional main 2 protection. Several teleprotection schemes ensure maximum selectivity and high-speed tripping time.

The units measure the delay time in the communication networks and adaptively match their measurements accordingly.

A special GPS-version allows the use of the relays in communication networks, where the delay time in the transmit and receive path may be quite different.

The 7SD5 has the following features:

- 2 full-scheme main protections in one unit (differential and distance protection)
- High-speed tripping 10 - 15 ms
- The serial protection data interfaces (R2R interfaces) of the relays can flexibly be adapted to the requirements of all communication media available.
- If the communication method is changed, flexible retrofitting of communication modules to the existing configuration is possible.
- Tolerates loss of one data connection in a ring topology (routing in 20 ms). The differential protection scheme is fully available in a chain topology.
- Browser-based commissioning tool.
- Fault locator for one and two terminal measurement for high accuracy on long lines with high load and high fault resistance.
- Capacitive charge current compensation increases the sensitivity of the differential protection on cables and long lines.

Function overview

Application

- Differential protection with phase-segregated measurement (87L, 87T)
- Sensitive measuring stage for high-resistance faults
- Non-switched distance protection with 6 measuring systems (21/21N)
- High resistance ground (earth)-fault protection for single and three-pole tripping (50N/51N/67N)
- Phase-selective intertripping (85)
- Tele (pilot) protection (85/21, 85/67N)
- Weak-infeed protection (27WI)
- Fault locator (FL)
- Power swing detection/tripping (68/68T)
- 3-stage overcurrent protection (50, 50N, 51, 51N)
- STUB bus protection (50 STUB)
- Switch-onto-fault protection (50HS)
- Over/undervoltage protection (59/27)
- Over/underfrequency protection (81O/U)
- Auto-reclosure (79)
- Synchro-check (25)
- Breaker failure protection (50BF)
- Overload protection (49)
- Lockout function (86)

Control functions

- Commands f. ctrl of CB and isolators

Monitoring functions

- Self-supervision of relay and protection data (R2R) communication
- Trip circuit supervision (74TC)
- Measured-value supervision
- Oscillographic fault recording
- Event logging/fault logging
- Switching statistics

Front design

- User-friendly local operation
- PC front port for relay setting
- Function keys and 14 LEDs f. local alarm

Communication interfaces

- 2 serial protection data (R2R) interfaces for ring and chain topology
- Front interface for connecting a PC
- System interface for connection to a control system via various protocols
  - IEC 60870-5-103
  - PROFIBUS-FMS/-DP and DNP 3.0
- Rear-side service/modem interface
- Time synchronization via IRIG-B or DCF77 or system interface

Application

ANSI		ANSI	
87L	Δ *I* for lines / cables	59 27	Overvoltage/undervoltage protection
87T	Δ *I* for lines / cables with transformers	81O/U	Over/underfrequency protection
85	Phase-selective intertrip, remote trip	25	Synchro-check
86	Lockout function	79	Single or three-pole auto-reclosure with new adaptive technology
21 21N	Distance protection	49	Overload protection
FL	Fault locator	50BF	Breaker failure protection
68 68T	Power swing detection/tripping	74TC	Trip circuit supervision
85/21	Teleprotection for distance protection	50-STUB	STUB bus protection
27WI	Weak-infeed protection		
50N 51N 67N	Directional earth(ground)-fault protection		
85/67N	Teleprotection for earth (ground)-fault protection		
50 50N 51 51N	Three-stage overcurrent protection		
50HS	Instantaneous high-current tripping (switch-onto-fault)		

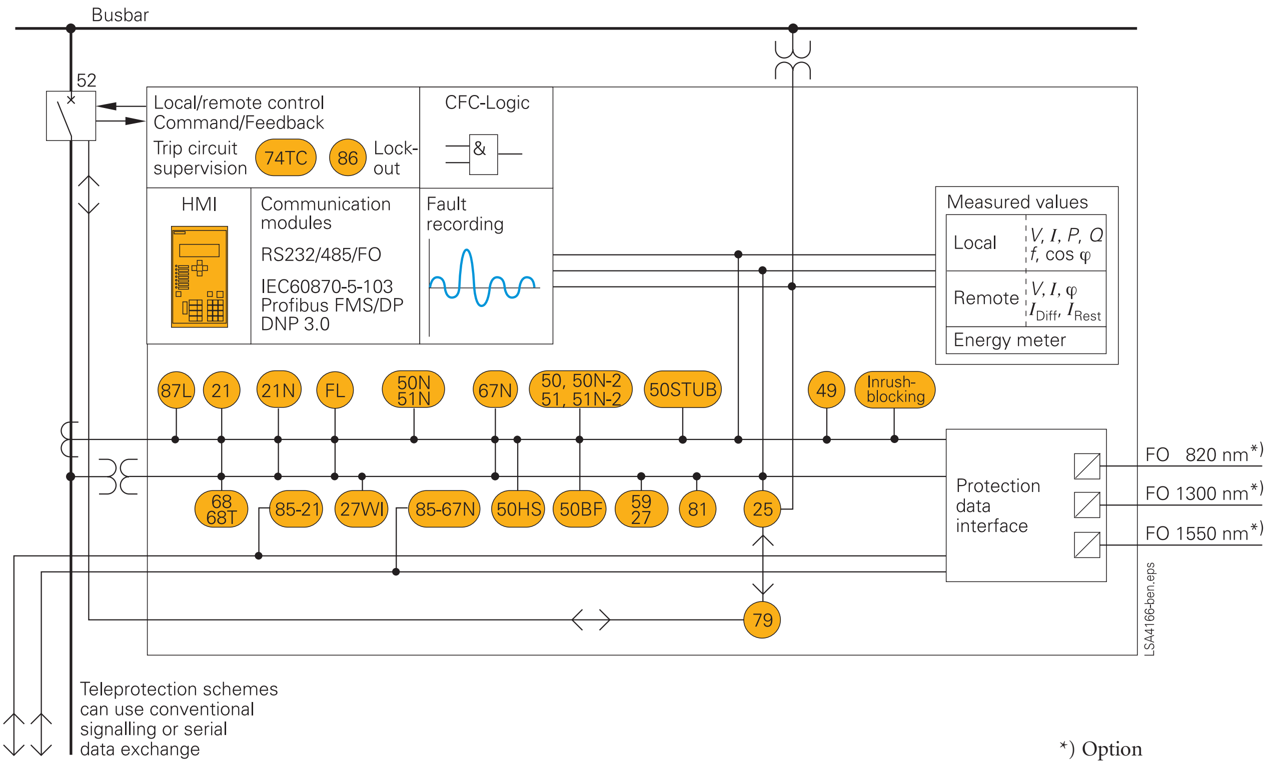


Fig. 7/38

Application

Typical applications

SIPROTEC 7SD5 is a full-scheme differential protection relay for two up to six line ends, incorporating all the additional functions for protection of overhead lines and cables at all voltage levels. Also transformers and compensation coils within the protection zone are protected. The 7SD5 is suitable for single-pole and three-pole tripping. The power system star point can be solid or impedance-grounded (earthed), resonant-earthed via Peterson coil or isolated. On the TAP-line, the 7SD5 differential relay is connected to current (CT) and optionally voltage (VT) transformers. For the differential functions, only CTs are necessary. By connecting the relay to VTs, the integrated "main 2" distance protection can be applied (full-scheme, non-switched). Therefore, no separate distance protection relay is required.

The link to the other relays is made by multi-mode or mono-mode FO cables. There are 4 optical modules available, which correspondingly cover:

- 820 nm, up to 1.5 km, multi-mode
- 820 nm, up to 3.5 km, multi-mode
- 1300 nm, up to 24 km, mono-mode
- 1300 nm, up to 60 km, mono-mode
- 1550 nm, up to 100 km, mono-mode

Direct fiber-optic connection offers high-speed data exchange with 512 kbit/s and improves the speed for remote signaling.

At the main line two differential relays are connected to CTs. The communication is made via a multiplexed communication network.

The 7SD5 offers many features to reliably and safely handle data exchange via communication networks.

Depending on the bandwidth available in the communication system 64, 128 or 512 kbits/s can be selected for the X21 (RS422) interface; the G703.1 interface works with 64 kbits/s.

The connection to the communication device is effected via cost-effective 820 nm interface with multi-mode FO cables. A communication converter converts the optical to electrical signals. This offers an interference-free and isolated connection between the relay and the communication device.

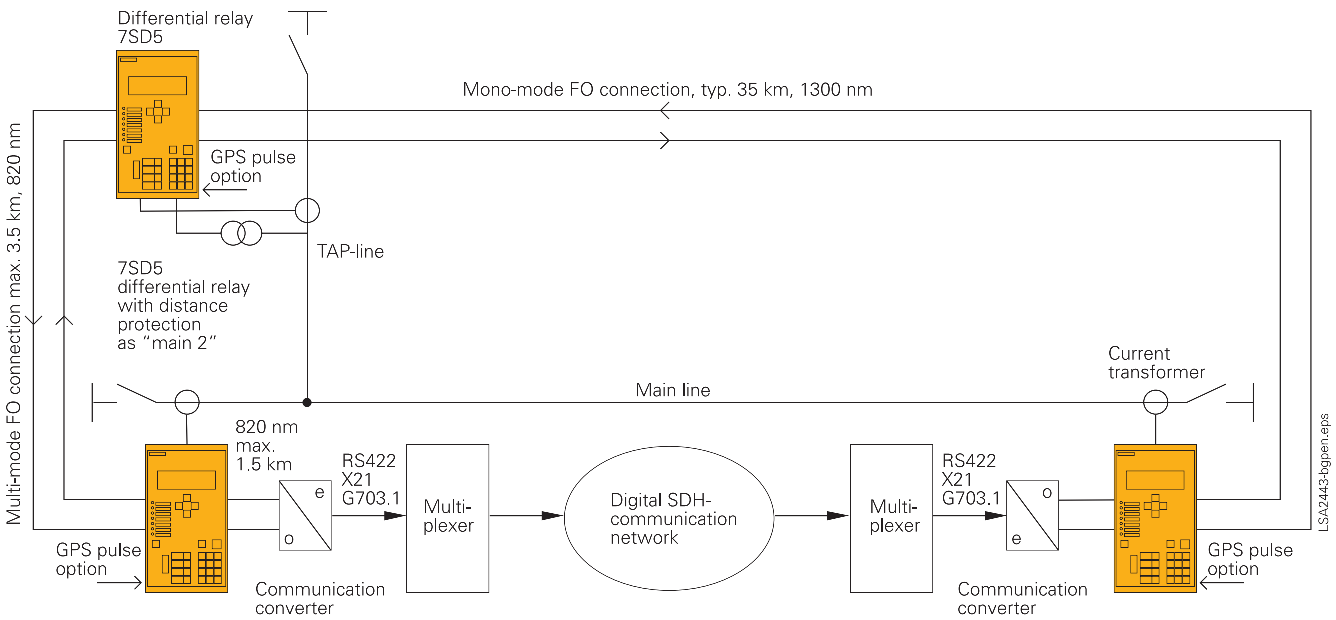


Fig. 7/39 Application for three line ends (Ring topology)

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user in view of a cost-effective power system management. The security and reliability of power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control. If the requirements for protection, control or interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.

The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

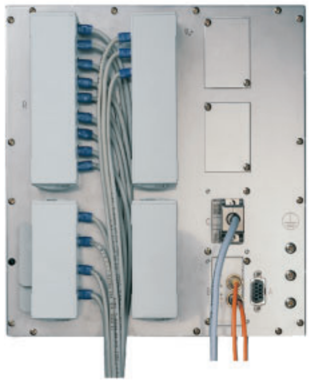
Construction

Connection techniques and housing with many advantages

1/3, 1/2, 2/3, and 1/1-rack sizes:
These are the available housing widths of the 7SA6 relays, referred to a 19" module frame system. This means that previous models can always be replaced. The height is a uniform 255 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs. Plug-in terminals are available as an option. It is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

LSP2174-afp.tif

Fig. 7/40
Flush-mounting housing with screw-type terminals



LSP2166-afp.tif

Fig. 7/41
Rear view of flush-mounting housing with covered connection terminals and wirings

LSP2219-afp.eps

Fig. 7/42
Surface-mounting housing with screw-type terminals

LSP2237-afp.tif

Fig. 7/43
Communication interfaces in a sloped case in a surface-mounting housing

Protection functions

Differential protection (ANSI 87L, 87T)

The differential protection function has the following features:

- It is possible to select the operating mode as "main" or as "main 1", if the back-up distance protection is activated as "main 2".
- Measurements are performed separately for each phase; thus the trip sensitivity is independent of the fault type.
- An adaptive, sensitive measurement method with high sensitivity for differential fault currents below the rated current offers the detection of highly resistive faults. This trip element uses special filters, which offers high security even with high level DC-components in the short-circuit current. The trip time of this stage is about 30 ms.
- A high-set differential trip stage which clears differential fault currents higher than the rated current within 10 – 15 ms offers fast tripping time and high-speed fault clearence time.
- When a long line or cable is switched on, transient charge currents load the line. To avoid a higher setting of the sensitive differential trip stage, this setpoint may be increased for a settable time. This offers greater sensitivity under normal load conditions.
- With the setting of the CT-errors the relay automatically calculates the restraint/stabilization current and adapts its permissible sensitivity according to the CT's data in the differential configuration, optimizing sensitivity.
- Different CT ratios at the line ends are handled inside the relay. The mismatch of 1 to 6 is allowed.
- The differential protection trip can be combined with an overcurrent pickup. Thus differential current and overcurrent lead to a final trip decision.
- Easy to set tripping characteristic. Because the relay works adaptively, only the setpoint $I_{Diff}>$ (sensitive stage) and $I_{Diff}>>$ (high-set current differential stage) must be set according to the charge current of the line/cable.
- With an optional capacitive charge current compensation, the sensitivity can be increased to 40 % of the normal setting of $I_{DIFF}>$. This function is recommended for long cables and long lines.
- Differential and restraint currents are monitored continuously during normal operation and are displayed as operational measurements.
- High stability during external faults even with different current transformers saturation level. For an external fault, only 5 ms saturation-free time are necessary to guarantee the stability of the differential configuration.
- With transformers or compensation coils in the protection zone, the sensitive trip stage can be blocked by an inrush detection function. It works with the second harmonic of the measured current which is compared with the fundamental component.
- With transformers in the protection zone, vector group adaptation and matching of different CT ratios are carried out in the relay. Additionally, the zero-sequence current flowing through an earthed neutral is eliminated from the differential measurement. The 7SD5 therefore works like a transformer differential relay, whereas the line ends may be far away.

Enhanced communication features for communication networks

The data required for the differential calculations are cyclically exchanged in full-duplex mode in form of synchronous, serial telegrams between the protection units. The telegrams are secured with CRC check sums, so that transmission errors in a communication network are immediately detected.

- Data communication is immune to electromagnetic interference because fiber-optic cables are employed in the critical region.
- Supervision of each individual incoming telegram and of the entire communication path between the units without additional equipment.
- Unambiguous identification of each unit is ensured by assignment of a settable communication address within a differential protection topology. Only those units mutually known to each other can cooperate. Incorrect interconnection of the communication links results in blocking of the protection system.
- Detection of reflected telegrams in the communication system.
- Detection of delay time changes in communication networks.

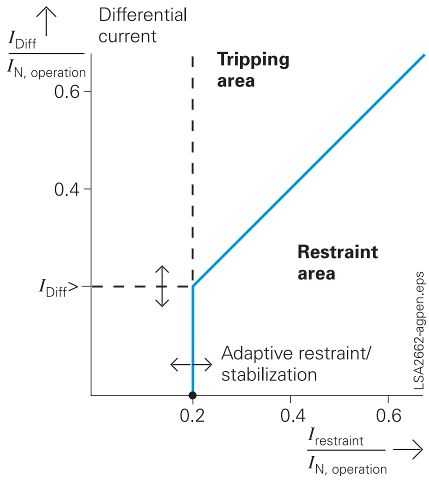


Fig. 7/44 Tripping characteristic

- Measurement of the delay time to the remote line ends with dynamic compensation of the delay in the differential measurement. Supervision of the maximum permissible delay time is included.
- Generation of alarms on heavily disturbed communication links. Faulty telegram counters are available as operational measurement.
- With a GPS high-precision 1-s pulse from a GPS receiver the relays can be synchronized with an absolute, exact time at each line end. In this way, the delay in the receive and transmit path can be measured exactly. With this optional feature the relay can be used in communication networks where this delay times are quite different.

Phase-selective intertrip and remote trip/indications

Normally the differential fault current is calculated for each line end nearly at the same time. This leads to fast and uniform tripping times. Under weak infeed conditions, especially when the differential function is combined with an overcurrent pickup a phase-selective intertrip offers a tripping of all line ends.

- 7SD5 has 4 intertrip signals which are transmitted in high-speed (< 20 ms) to the other line ends. These intertrip signals can also be initiated by an external relay via binary inputs and therefore be used to indicate, for example, a directional decision of the backup distance relay.
- In addition, 4 high-speed remote trip signals are available, which may be initiated by an external or internal event.
- 24 remote signals can be freely assigned to inputs and outputs at each line end and are circulating between the different devices.

7

Protection functions

Communication topologies / modes of operation

The differential relays may work in a ring or daisy chain line topology. Use of a test mode offer advantages under commissioning and service conditions.

- The system tolerates the loss of one data connection in a ring topology. The ring topology is rerouted within 20 ms forming then a chain topology, while the differential protection function is immediately reactivated.
- When the communication connections need to be reduced or when these are not available, the whole system is able to function without interruption as chain topology. At the line ends, only cost-effective 7SD5 relays with one protection data interface are necessary for this application.
- The two-end line is a special case, because when the main connection is interrupted, the communication switches over from a main path to a secondary path. This hot standby transmission function ensures a high availability of the system and protects differential protection against communication route failure on important lines.
- In a ring topology, one line end can be logged out from the differential protection topology for service or maintenance reasons by a signal via binary input. Checks for the breaker position and load current are made before this logout is initiated. In a chain topology, the relays at the end of the line can be logged out from the differential protection topology.
- The whole configuration can be set up into a test mode. All functions and indications are available except the breakers are not tripped. The local relay can be tested and no trip or intertrip reaction is effected by the other relays.

Thermal overload protection (ANSI 49)

A built-in overload protection with a current and thermal alarm stage is provided for the thermal protection of cables and transformers.

The trip time characteristics are exponential functions according to IEC 60255-8. The preload is thus considered in the trip times for overloads.

An adjustable alarm stage can initiate an alarm before tripping is initiated.

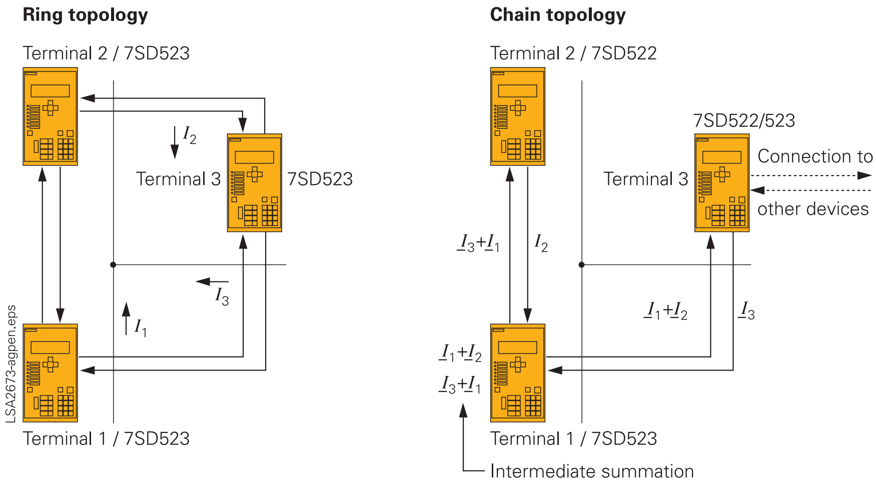


Fig. 7/45 Differential protection in ring or chain topology

Protection functions

Distance protection (ANSI 21, 21N)

7SD5 provides a non-switched distance protection featuring all well-proven algogrithms of 7SA522 and 7SA6. It is possible to select the operating mode "main" or "main 2", if the back-up differential is activated as "main 1". By parallel calculation and monitoring of all six impedance loops, a high degree of sensitivity and selectivity is achieved for all types of faults. The shortest tripping time is less than one cycle. All methods of neutral-point connection (resonant earthing, isolated, solid or low-resistance earthing) are reliably dealt with. Single and three-pole tripping is possible. Overhead lines can be equipped with or without series capacitor compensation.

Quadrilateral and mho characteristics

The 7SD5 relay provides quadrilateral as well as mho zone characteristics. Both characteristics can be used separately for phase and ground (earth) faults. Resistance ground (earth) faults can, for instance, be covered with the quadrilateral characteristic and phase faults with the mho characteristic.

Alternatively, the quadrilateral characteristic is available with 4 different pickup methods:

- Overcurrent pickup *I*>>
- Voltage-dependent overcurrent pickup *V*/*I*
- Voltage-dependent and phase angle-dependent overcurrent pickup *V*/*I*/φ
- Impedance pickup *Z*<

Load zone

In order to guarantee a reliable discrimination between load operation and short-circuit - especially on long high loaded lines - the relay is equipped with a selectable load encroachment characteristic. Impedances within this load encroachment characteristic prevent the distance zones from unwanted tripping.

Absolute phase-selectivity

The distance protection incorporates a well-proven highly sophisticated phase selection algorithm. The pickup of unfaulted loops is reliably eliminated to prevent the adverse influence of currents and voltages in the fault-free loops. This phase selection algorithm achieves single-pole tripping and correct distance measurement in a wide application range.

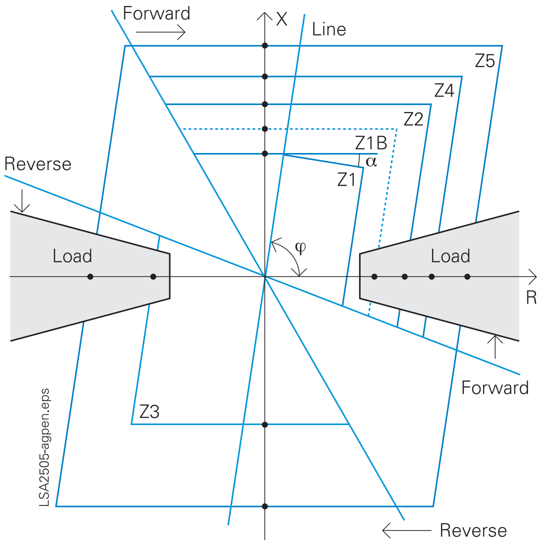


Fig. 7/46
Distance protection: quadrilateral characteristic

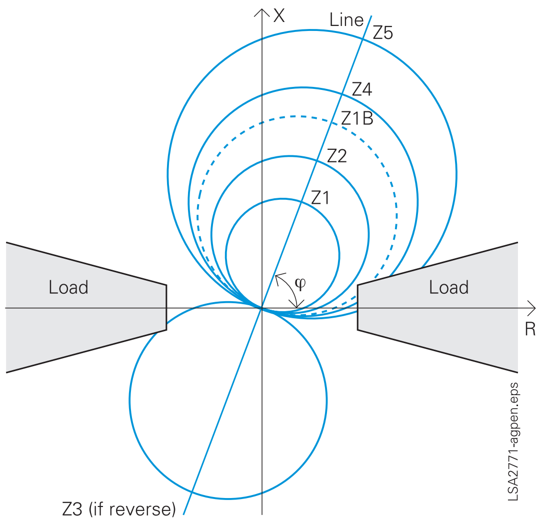


Fig. 7/47
Distance protection: mho characteristic

Parallel line compensation

The influence of wrong distance measurement due to parallel lines can be compensated by feeding the neutral current of the parallel line to the relay. Parallel line compensation can be used for distance protection as well as for fault locating.

6 distance zones

Five independent distance zones and one separate overreach zone are available. Each distance zone has dedicated time stages, partly separate for single-phase or multi-phase faults. Ground (earth) faults are detected by monitoring the neutral current $3I_0$ and the zero-sequence voltage $3V_0$.

The quadrilateral tripping characteristic permits separate setting of the reactance *X* and the resistance *R*. The resistance section *R* can be set separately for faults with and without earth involvement. This characteristic has therefore an optimal performance in case of faults with fault resistance. The distance zones can be set forward, reverse or non-directional. Sound phase polarization and voltage memory provides a dynamically unlimited directional sensitivity.

Mho

The mho tripping characteristic provides sound phase respectively memory polarization for all distance zones. The example in this figure shows the characteristic for a forward fault where the mho circle expands to the source impedance but never more than the selected impedance reach. This mho circle expansion guarantees safe

Protection functions

Elimination of interference signals

Digital filters render the unit immune to interference signals contained in the measured values. In particular, the influence of DC components, capacitive voltage transformers and frequency changes is considerably reduced. A special measuring method is employed in order to assure protection selectivity during saturation of the current transformers.

Measuring voltage monitoring

Tripping of the distance protection is blocked automatically in the event of failure of the measuring voltage, thus preventing spurious tripping.

The measuring voltage is monitored by the integrated fuse failure monitor. Distance protection is blocked if either the fuse failure monitor or the auxiliary contact of the voltage transformer protection switch operates and, in this case, the EMERGENCY definite-time overcurrent protection can be activated.

Power swing detection (ANSI 68, 68T)

Dynamic transient reactions, for instance short-circuits, load fluctuations, auto-reclosures or switching operations can cause power swings in the transmission network. During power swings, large currents along with small voltages can cause unwanted tripping of distance protection relays. To avoid uncontrolled tripping of the distance protection and to achieve controlled tripping in the event of loss of synchronism, the 7SD5 relay is equipped with an efficient power swing detection function. Power swings can be detected under symmetrical load conditions as well as during single-pole auto-reclosures.

Tele (pilot) protection for distance protection (ANSI 85-21)

A teleprotection function is available for fast clearance of faults up to 100 % of the line length. The following operating modes may be selected:

- PUTT, permissive underreaching zone transfer trip
- POTT, permissive overreaching zone transfer trip
- UNBLOCKING
- BLOCKING
- Directional comparison pickup
- Pilot-wire comparison
- Reverse interlocking

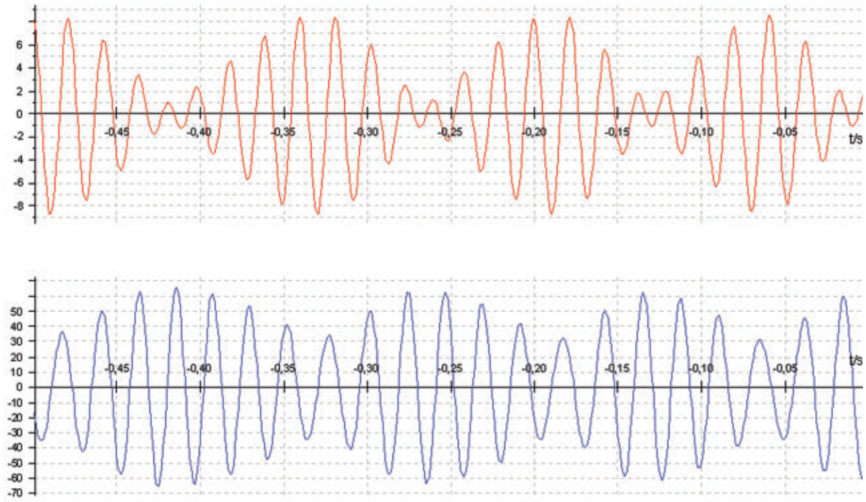


Fig. 7/48

Power swing current and voltage wave forms

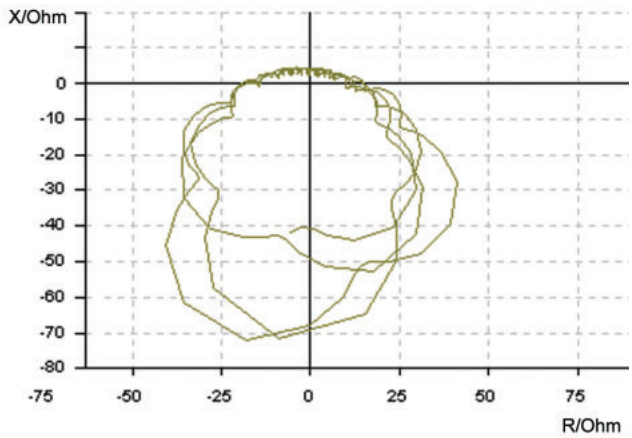


Fig. 7/49

Power swing circle diagram

- DUTT, direct underreaching zone transfer trip (together with Direct Transfer Trip function)

The carrier send and receive signals are available as binary inputs and outputs and can be freely assigned to each physical relay input or output. At least one channel is required for each direction.

Common transmission channels are power-line carrier, microwave radio and fiber-optic links. The serial protection data interface can be used for direct connection to a digital communication network, fiber-optic or pilot-wire link as well.

7SD5 also permits the transfer of phase-selective signals. This feature is particularly advantageous as it ensures reliable single-pole tripping, if two single-pole faults occur on different lines. The transmission methods are suitable also for lines with three ends (three-terminal lines).

Phase-selective transmission is also possible with multi-end applications, if some user-specific linkages are implemented by way of the integrated CFC logic. During disturbances in the transmission receiver or on the transmission circuit, the teleprotection function can be blocked by a binary input signal without losing the zone selectivity. The control of the overreach zone Z1B (zone extension) can be switched over to the auto-reclosure function.
A transient blocking function (Current reversal guard) is provided in order to suppress interference signals during tripping of parallel lines.

Protection functions

Direct transfer tripping

Under certain conditions on the power system it is necessary to execute remote tripping of the circuit-breaker. The 7SD5 relay is equipped with phase-selective intertripping signal inputs and outputs.

Weak-infeed protection: echo and/or trip (ANSI 27 WI)

To prevent delayed tripping of permissive schemes during weak or zero infeed situations, an echo function is provided.
If no fault detector is picked up at the weak-infeed end of the line, the signal received here is returned as echo to allow accelerated tripping at the strong infeed end of the line. It is also possible to initiate tripping at the weak-infeed end. A phase-selective 1-pole or 3-pole trip is issued if a permissive trip signal (POTT or Unblocking) is received and if the phase-earth voltage drops correspondingly. As an option, the weak-infeed logic can be equipped according to a French specification.

Directional ground(earth)-fault protection for high-resistance faults (ANSI 50N, 51N, 67N)

In grounded (earthed) networks, it may happen that the distance protection sensitivity is not sufficient to detect high-resistance ground (earth) faults. The 7SD5 protection relay has therefore protection functions for faults of this nature.

The ground (earth)-fault overcurrent protection can be used with 3 definite-time stages and one inverse-time stage (IDMT). A 4th definite-time stage can be applied instead of the 1st inverse-time stage.

Inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided (see "Technical data"). An additional logarithmic inverse-time characteristic is also available.

The direction decision can be determined by the neutral current and the zero-sequence voltage or by the negative-sequence components V_2 and I_2. In addition or as an alternative to the directional determination with zero-sequence voltage, the star-point current of a grounded (earthed) power transformer may also be used for polarization. Dual polarization applications can therefore be fulfilled. Alternatively, the direction can be determined by evaluation of zero-sequence power. Each overcurrent stage can be set in forward or reverse direction or for both directions (non-directional). As an option the 7SD5 relay can be provided with a sensitive neutral (residual) current transformer. This feature provides a measuring range for the neutral (residual) current from 5 mA to 100 A with a nominal relay current of 1 A and from 5 mA to 500 A with a nominal relay current of 5 A. Thus the ground (earth)-fault overcurrent protection can be applied with extreme sensitivity.

The function is equipped with special digital filter algorithms, providing the elimination of higher harmonics. This feature is particularly important for low zero-sequence fault currents which usually have a high content of 3rd and 5th harmonics. Inrush stabilization and instantaneous switch-onto-fault trip can be activated separately for each stage as well.

Different operating modes can be selected. The ground(earth)-fault protection is suitable for three-phase and, optionally, for single-phase tripping by means of a sophisticated phase selector. It may be blocked during the dead time of single-pole auto-reclose cycles or during pickup of the distance protection.

Tele (pilot) protection for directional ground(earth)-fault protection (ANSI 85-67N)

The directional ground(earth)-fault overcurrent protection can be combined with one of the following teleprotection schemes:

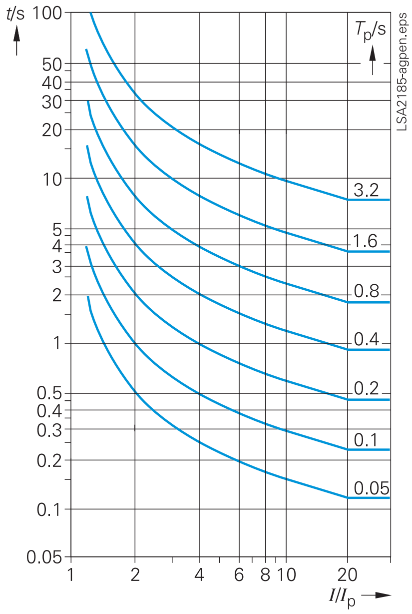
- Directional comparison
- BLOCKING
- UNBLOCKING

The transient blocking function (current reversal guard) is also provided in order to suppress interference signals during tripping of parallel lines.

The pilot functions for distance protection and for ground(earth)-fault protection can use the same signaling channel or two separate and redundant channels.

Backup overcurrent protection (ANSI 50, 50N, 51, 51N)

The 7SD5 provides a backup overcurrent protection. Two definite-time stages and one inverse-time stage (IDMTL) are available, separately for phase currents and for the neutral (residual) current. Two operating modes are selectable. The function can run in parallel to the differential protection and the distance protection or only during



$$t = \frac{0.14}{\left(I/I_p\right)^{0.02} - 1} \cdot T_p$$

Fig. 7/50 Normal inverse

interruption of the protection communication and/or failure of the voltage in the VT secondary circuit (emergency operation). The secondary voltage failure can be detected by the integrated fuse failure monitor or via a binary input from a VT miniature circuit-breaker (VT m.c.b. trip).

The following inverse-time characteristics according to IEC 60255-3 and ANSI/IEEE are provided:

- Inverse
- Short inverse
- Long inverse
- Moderately inverse
- Very inverse
- Extremely inverse
- Definite inverse

STUB bus overcurrent protection (ANSI 50(N)-STUB)

The STUB bus overcurrent protection is a separate definite-time overcurrent stage. It can be activated from a binary input signaling the open line isolator (disconnector) is open. Settings are available for phase and ground (earth)-faults.

Protection functions

Instantaneous high-speed switch-onto-fault overcurrent protection (ANSI 50HS)

Instantaneous tripping is possible when energizing a faulty line. In the event of large fault currents, the high-speed switch-onto-fault overcurrent stage can initiate very fast 3-pole tripping.

With lower fault currents, instantaneous tripping after switch-onto-fault is also possible

- if the breaker positions at the line ends are monitored and connected to the relays. This breaker position monitor offers a high-speed trip during switch-onto-fault conditions.
- with the overreach distance zone Z1B or just with pickup in any zone.

The switch-onto-fault initiation can be detected via the binary input "manual close" or automatically via measurement.

Fault locator

The integrated fault locator calculates the fault impedance and the distance-to-fault. The result is displayed in ohms, miles, kilometers or in percent of the line length. Parallel line and load current compensation is also available.

As an option for a line with two ends, a fault locator function with measurement at both ends of the line is available.
Thanks to this feature, accuracy of measurement on long lines under high load conditions and high fault resistances is considerably increased.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

A voltage rise can occur on long lines that are operating at no-load or are only lightly loaded. The 7SD5 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4^{th} voltage input or be derived from the phase voltages.
- Positive-sequence overvoltage of the local end or calculated for the remote end of the line (compounding).
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7SD5 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (45 to 55, 55 to 65 Hz). There are four elements (selectable as overfrequency or underfrequency) and each element can be delayed separately.

Breaker failure protection (ANSI 50BF)

The 7SD5 relay incorporates a two-stage breaker failure protection to detect the failure of tripping command execution, for example due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command is generated. The breaker failure protection can be initiated by all integrated protection functions as well as by external devices via binary input signals.

Auto-reclosure (ANSI 79)

The 7SD5 relay is equipped with an auto-reclose function (AR). The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and for 2-phase faults without earth, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults without earth and 3-pole auto-reclosure for other faults
- Multiple-shot auto-reclosure
- Interaction with an external device for auto-reclosure via binary inputs and outputs
- Control of the integrated AR function by external protection
- Adaptive auto-reclosure. Only one line end is closed after the dead time. If the fault persists this line end is switched off. Otherwise the other line ends are closed via a command over the communication links. This avoids stress when heavy fault currents are fed from all line ends again.
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

Integration of auto-reclosure in the feeder protection allows evaluation of the line-side voltages. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure).
- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).

Protection functions

- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no tele-protection method is employed: When faults within the zone extension, but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism the function releases the CLOSE command. Alternatively, reclosing can be enabled for different criteria, e.g., checking that the busbar or line is not carrying a voltage (dead line or dead bus).

Monitoring and supervision functions

The 7SD5 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.

Current transformer / Monitoring functions

A broken wire between the CTs and relay inputs under load may lead to maloperation of a differential relay if the load current exceeds the differential setpoint. The 7SD5 provides fast broken wire supervision which immediatelly blocks all line ends if a broken wire condition is measured by a local relay. This avoids maloperation due to broken wire condition. Only the phase where the broken wire is detected is blocked. The other phases remain under differential operation.

Fuse failure monitoring

If any measured voltage is not present due to short-circuit or open circuit in the voltage transformer secondary circuit the distance protection would respond with an unwanted trip due to this loss of voltage. This secondary voltage interruption can be detected by means of the integrated fuse failure monitor. Immediate blocking of distance protection is provided for all types of secondary voltage failures.

Additional measurement supervision functions are

- Symmetry of voltages and currents
- Summation of currents and voltages

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only be issued after the lockout state is reset.

Local measured values

The measured values are calculated from the measured current and voltage signals along with the power factor (cos φ), the frequency, the active and reactive power. Measured values are displayed as primary or secondary values or in percent of the specific line rated current and voltage. The relay uses a 20 bit high-resolution AD converter and the analog inputs are factory-calibrated, so a high accuracy is reached. The following values are available for measured-value processing:

- Currents 3 x I_{Phase}, 3 I_0, I_E, $I_{E\,sensitive}$
- Voltages 3 x $V_{Phase\text{-}Ground}$, 3 x $V_{Phase\text{-}Phase}$, 3 V_0, V_{en}, V_{SYNC}, V_{COMP}
- Symmetrical components I_1, I_2, V_1, V_2
- Real power P (Watt), reactive power Q (Var), apparent power S (VA)
- Power factor PF (= cos φ)
- Frequency f
- Differential and restraint current per phase
- Load impedances with directional indication
  3 x $R_{Phase\text{-}Ground}$, $X_{Phase\text{-}Ground}$
  3 x $R_{Phase\text{-}Phase}$, $X_{Phase\text{-}Phase}$
- Long term mean values
  3 x I_{Phase}; I_1; P; P+; P-; Q; Q+; Q-; S
- Minimum/maximum memory
  3 x I_{Phase}; I_1; 3 x $V_{Phase\text{-}Ground}$
  3 x $V_{Phase\text{-}Phase}$, 3V_0; V_1; P+; P-; Q+; Q-; S; f; power factor (+); power factor (-); from mean values
  3 x I_{Phase}; I_1; P; Q; S
- Energy meters
  W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
- Availability of the data connection to the remote line ends per minute and per hour
- Regarding delay time measuring with the GPS-version the absolute time for transmit and receive path is displayed separately.

Limit value monitoring: Limit values are monitored by means of the CFC. Commands can be derived from these limit value indications.

Protection functions

Measured values at remote line ends

Every two seconds the currents and voltages are freezed at the same time at all line ends and transmitted via the communication link. At a local line end, currents and voltages are thus available with their amount and phases (angle) locally and remotely. This allows checking the whole configuration under load conditions. In addition, the differential and restraint currents are also displayed. Important communication measurements, such as delay time or faulty telegrams per minute/hour are also available as measurements. These measured values can be processed with the help of the CFC logic editor.

Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be displayed and activated directly. This can simplify the wiring check significantly for the user.

Furthermore, all currents and optional voltages and phases are available via communication link at the local relay and are displayed in the relay, with DIGSI 4 or a special commissioning program running in a standard browser (e.g. Internet Explorer, Netscape Navigator).

The operational and fault events and fault records from all line ends share a common time tagging which allows to compare events registered in the different line ends on a common time base.

Browser-based commissioning tool

The 7SD5 provides a commissioning and test program which runs on a standard Internet browser (no special software is required at the PC). This program shows the protection topology and comprehensive measurements from local and remote line ends. Local and remote measurements are shown as phasors and the breaker positions of each line end are depicted. It is possible to check the correct connection of the current transformers or the correct vector group of a transformer.
Stability can be checked by using the operating characteristic as well as the calculated differential and restraint values in the browser windows.
If the distance protection is active, then the valid zone characteristic (quadrilateral/mho) is displayed.

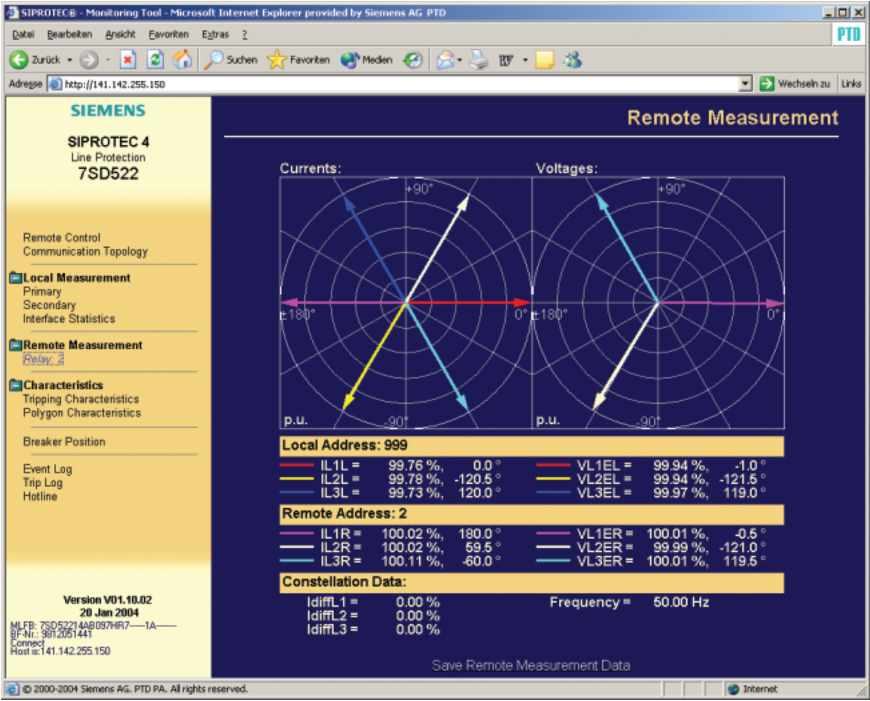


Fig. 7/51
Browser-aided commissioning: Phasor diagram

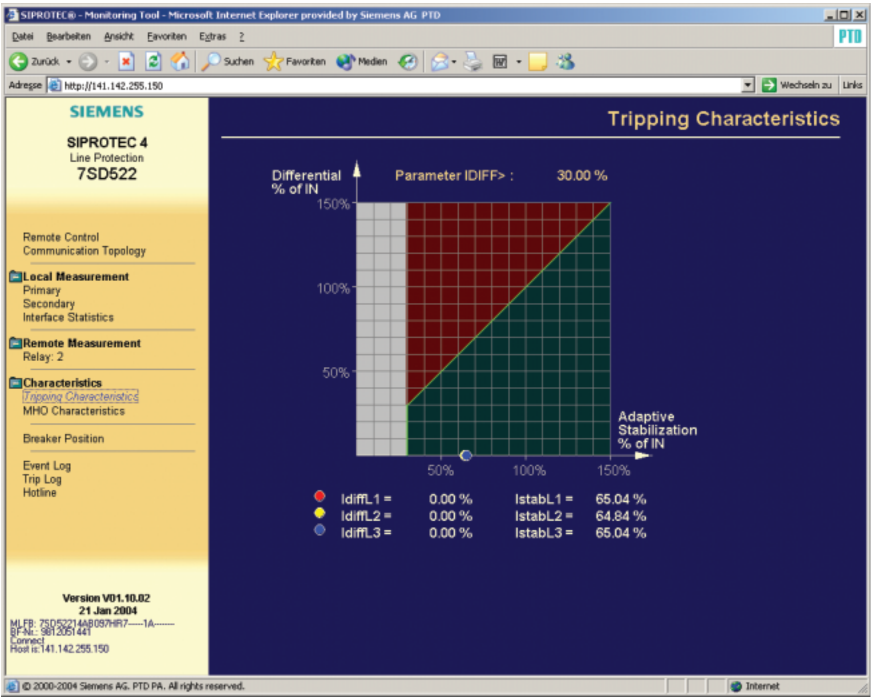


Fig. 7/52
Browser-aided commissioning:
Differential protection tripping characteristic

Event log and trip log messages are also available. Remote control can be used, if the local front panel cannot be accessed.

7

Protection functions

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit-breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.

Rear-mounted interfaces

Two communication modules located on the rear of the unit incorporate optional equipment complements and readily permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces.

The interfaces make provision for the following applications:

- Service /modem interface
  By means of the RS232/RS485 or optical interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4 or standard browser. Remote operation is possible on connection of a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned power plants.
  With the optical version, centralized operation can be implemented by means of a star coupler.
- System interface
  This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7SD5, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to "Commissioning program"). The relays include a small Web server that sends its HTML pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 60870-5-103, PROFIBUS-FMS/-DP, DNP 3.0, Ethernet[1], DIGSI, etc.) are required, such demands can be met.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

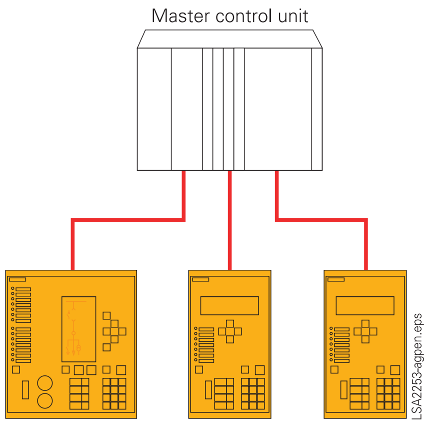


Fig. 7/53
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

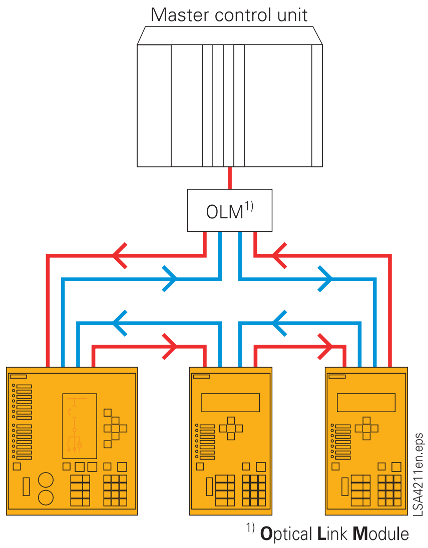


Fig. 7/54
Bus structure: Fiber-optic double ring circuit

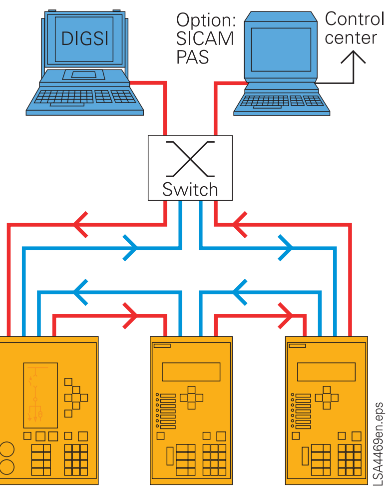


Fig. 7/55
Bus structure for station bus with Ethernet and IEC 61850

1) In the course of preparation

Communication

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area. IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized communication system (EN 50170). PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world.

Connection to a SIMATIC S5/S7 programmable controller is made on the basis of the data obtained (e.g. fault recording, fault data, measured values and control functionality) via SICAM energy automation system or via PROFIBUS-DP.

PROFIBUS-DP

PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

Ethernet / IEC 61850 [1)]

Ethernet/IEC 61850 application-specific profile for energy automation applications is currently in course of preparation.
As soon as standardization work has been completed, SIPROTEC 4 units will be upgraded to meet the requirements of the new standard. Retrofitting can be carried out simply by insertion of an Ethernet communication module.

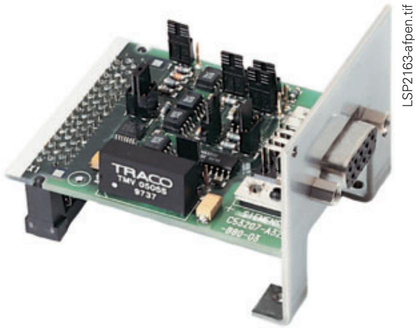


Fig. 7/56
R232/RS485 electrical communication module

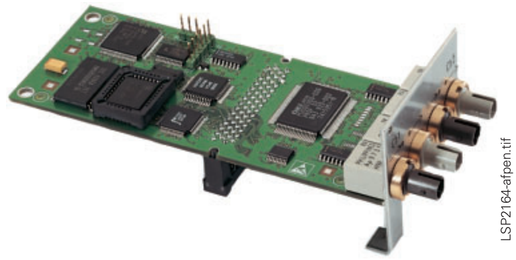


Fig. 7/57
Communication module, optical double-ring

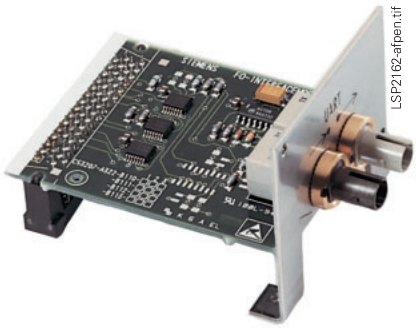


Fig. 7/58
Fiber-optic communication module

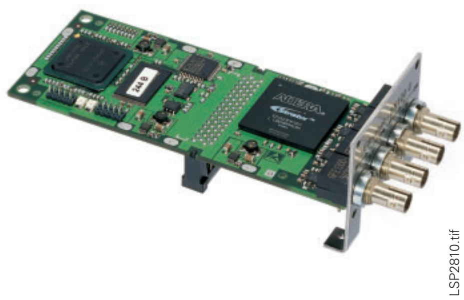


Fig. 7/57a
Fiber-optic Ethernet communication module for IEC 61850 with integrated Ethernet switch

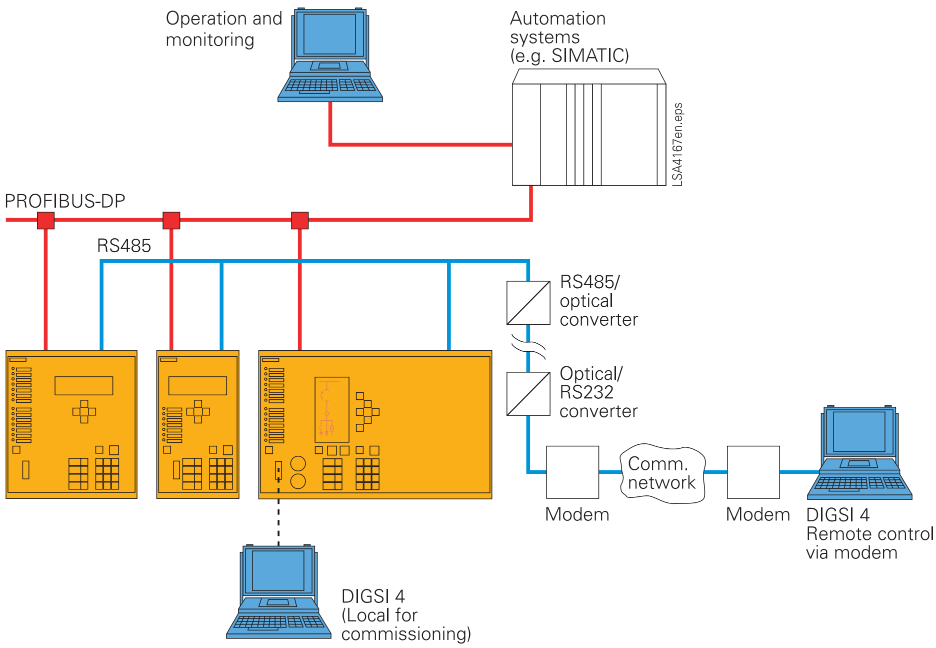


Fig. 7/59
System solution: Communications

1) In course of preparation.

Communication

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems. Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the protection unit.

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

Serial protection data interface (R2R interface)

As an option, the 7SD5 provides one or two protection data interfaces to cover two up to six line end applications in ring or chain topology and hot standby communication between two line ends.

In addition to the differential protection function, other protection functions can use this interface to increase selectivity and sensitivity as well as covering advanced applications.

- Fast phase-selective teleprotection signaling for distance protection, optionally with POTT or PUTT schemes
- Two and three-terminal line applications can be implemented without additional logic
- Signaling for directional ground(earth)-fault protection – directional comparison for high-resistance faults in solidly earthed systems
- Echo function
- Interclose command transfer with the auto-reclosure "Adaptive dead time" (ADT) mode
- 28 remote signals for fast transfer of binary signals
- Flexible utilization of the communication channels by means of the programmable CFC logic.

The protection data interfaces have different options to cover new and existing communication infrastructures.

- FO5[1)], OMA1[2)] module:
  820 nm fiber-optic interface with clock recovery/ST connectors for direct connection with multi-mode FO cable up to 1.5 km for the connection to a communication converter.
- FO6[1)], OMA2[2)] module:
  820 nm fiber-optic interface/ST connectors for direct connection up to 3.5 km with multi-mode FO cable.

New fiber-optic interfaces, series FO1x

- FO17[1)]: For direct connection up to 24 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO18[1)]: For direct connection up to 60 km[3)], 1300 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector
- FO19[1)]: For direct connection up to 100 km[3)], 1550 nm, for mono-mode fiber 9/125 µm, LC-Duplex connector

The link to a multiplexed communication network is made by separate communication converters (7XV5662). These have a fiber-optic interface with 820 nm and 2 ST connectors to the protection relay. The link to the communication network is optionally an electrical X21 or a G703.1 interface.

For operation via copper wire communication (pilot wires or twisted telephone pair), a modern communication converter for copper cables is available. This operates with both the two-wire and three-wire copper connections which were used by conventional differential protection systems before. The communication converter for copper cables is designed for 5 kV insulation voltage. An additional 20 kV isolation transformer can extend the field of applications of this technique into ranges with higher insulation voltage requirements. The connection via FO cable to the relay is interference-free. With SIPROTEC 4 and the communication converter for copper cables a digital follow-up technique is available for two-wire protection systems (typical 15 km) and all three-wire protection systems using existing copper communication links.

Furthermore, a communication converter is available, which enables the link to an ISDN connection via the S0-bus.

Communication data:

- 32-bit CRC-check according to CCITT and ITU
- Each protection relay possesses a unique relay address
- Continuous communication link supervision: Individual faulty data telegrams do not constitute an immediate danger, if they occur only sporadically. The statistical availability, per minute and hour, of the serial protection data interface can be displayed.
- Supported network interfaces G703.1 with 64 kbit/s; X21/RS422 with 64 or 128 or 512 kbit/s
- Max. channel delay time 0.1 ms to 30 ms (in steps of 0.1 ms)
- Protocol HDLC

1) For flush-mounting housing.
2) For surface-mounting housing.
3) For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Communication

Communication possibilities between relays

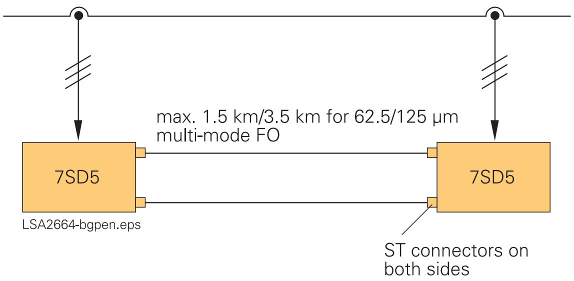


Fig. 7/58
Direct optical link up to 1.5 km/3.5 km, 820 nm

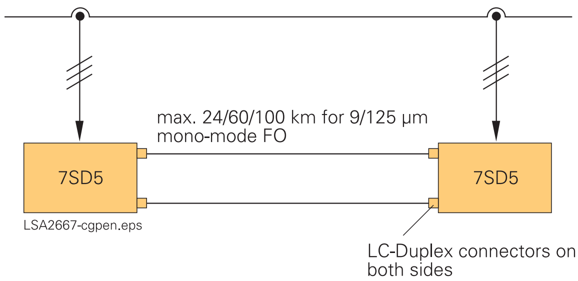


Fig. 7/59
Direct optical link up to 25/60 km with 1300 nm
or up to 100 km with 1550 nm

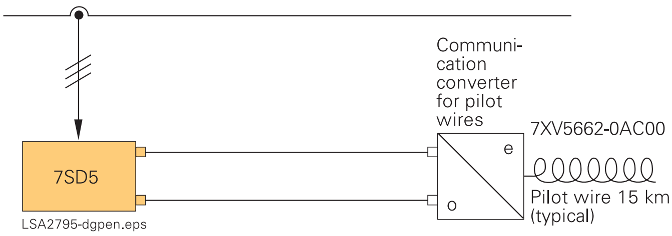


Fig. 7/61
Connection to a pilot wire

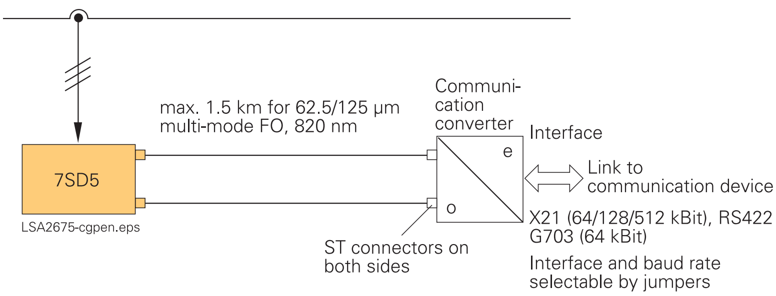


Fig. 7/60
Connection to a communication network

7

Typical connection

Typical connection for current and voltage transformers

3 phase current transformers with neutral point in the line direction, I_4 connected as summation current transformer ($=3I_0$): Holmgreen circuit

3 voltage transformers, without connection of the broken (open) delta winding on the line side; the $3V_0$ voltage is derived internally.

Note:
Voltage inputs are always available in the relay. But there is no need to connect it to voltage transformers for the differential protection function.

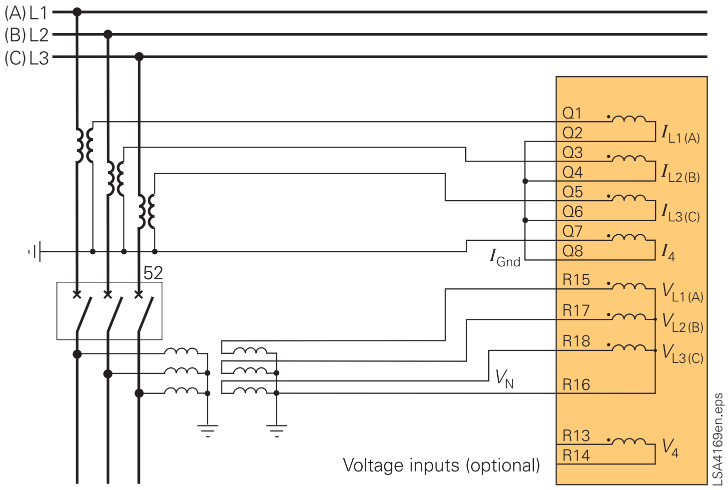


Fig. 7/62
Example of connection for current and voltage transformers

Alternative current measurement

The 3 phase current transformers are connected in the usual manner. The neutral point is in line direction. I_4 is connected to a separate neutral core-balance CT, thus permitting a high sensitive $3I_0$ measurement.

Note: Terminal Q7 of the I_4 transformer must be connected to the terminal of the core-balance CT pointing in the same direction as the neutral point of the phase current transformers (in this case in line direction). The voltage connection is effected in accordance with Fig. 7/68, 7/72 or 7/73.

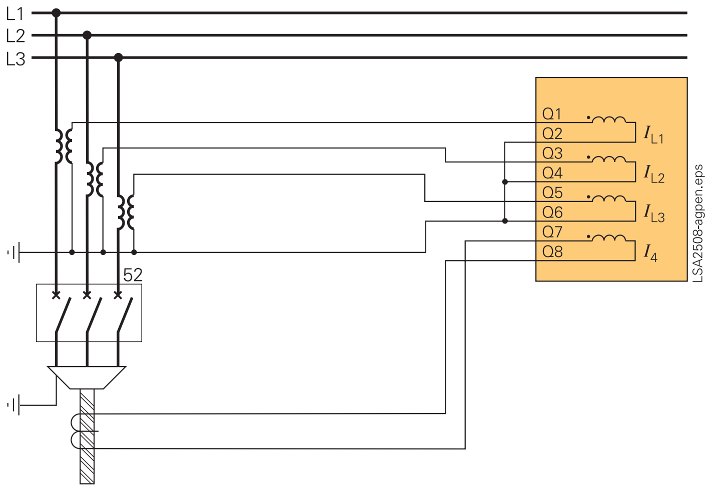


Fig. 7/63
Alternative connection of current transformers for sensitive ground(earth)-current measuring with core-balance current transformers

Typical connection

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to a current transformer in the neutral point of a grounded (earthed) transformer for directional ground(earth)-fault protection. The voltage connection is effected in accordance with Fig. 7/68, 7/72 or 7/73.

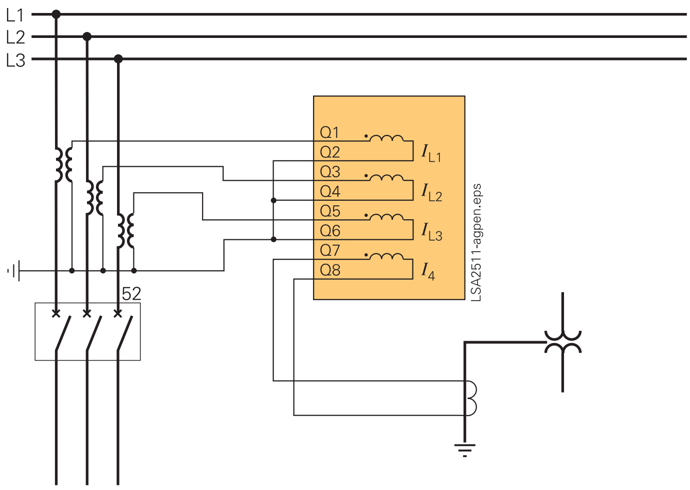


Fig. 7/64 Alternative connection of current transformers for measuring neutral current of a grounded (earthed) power transformer

Alternative current connection

3 phase current transformers with neutral point in the line direction, I_4 connected to the summation current of the parallel line for parallel line compensation on overhead lines. The voltage connection is effected in accordance with Fig. 7/68, 7/72 or 7/73.

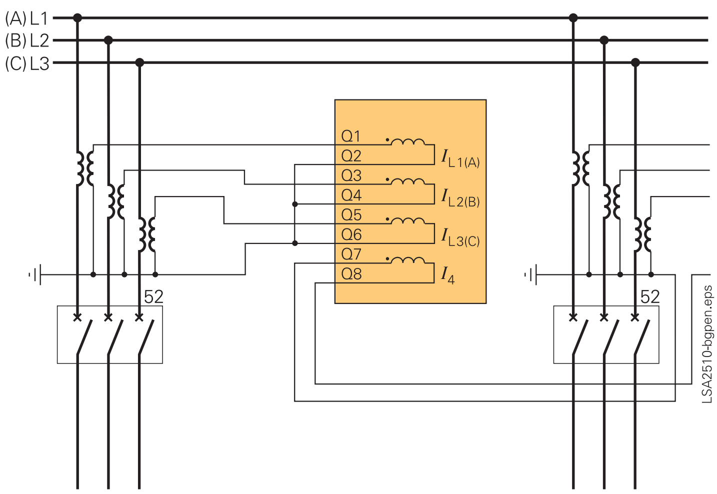


Fig. 7/65 Alternative connection of current transformers for measuring the ground (earth) current of a parallel line

Typical connection

Alternative voltage connection

3 phase voltage transformers, V_4 connected to broken (open) delta winding (V_{en}) for additional summation voltage monitoring and ground(earth)-fault directional protection. The current connection is effected in accordance with Fig. 7/68, 7/69, 7/70 and 7/71.

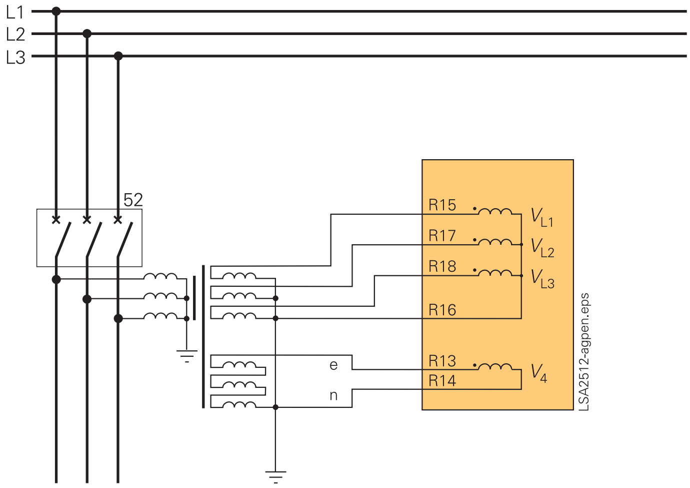


Fig. 7/66 Alternative connection of voltage transformers for measuring the displacement voltage (e-n voltage)

Alternative voltage connection

3 phase voltage transformers, V_4 connected to busbar voltage transformer for synchro-check.

Note: Any phase-to-phase or phase-to-ground(earth) voltage may be employed as the busbar voltage. Parameterization is carried out on the unit. The current connection is effected in accordance with Fig. 7/68, 7/69, 7/70 and 7/71.

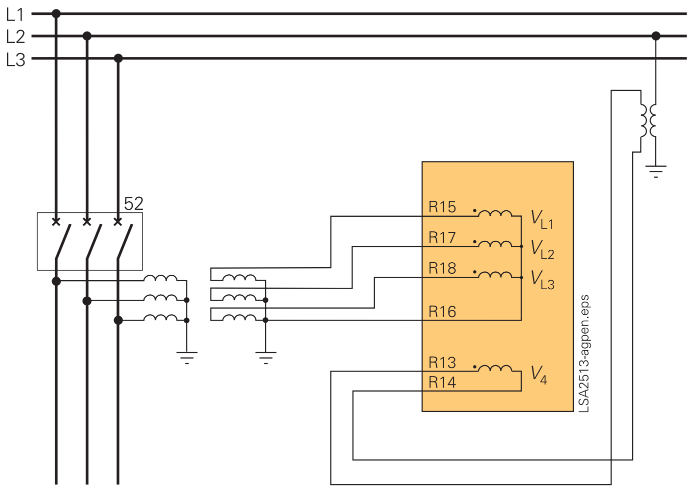


Fig. 7/67 Alternative connection of voltage transformers for measuring the busbar voltage

Technical data

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_N	1 or 5 A (selectable, controlled by firmware)
Rated voltage	80 to 125 V (selectable)
Power consumption	
In CT circuits with I_N = 1 A	Approx. 0.05 VA
In CT circuits with I_N = 5 A	Approx. 0.30 VA
In VT circuits	Approx. 0.10 VA
Thermal overload capacity	
In CT circuits	100 x I_N for 1 s 30 x I_N for 10 s 4 x I_N continuous
In VT circuits	230 V, continuous per phase
Dynamic overload capacity	
In CT circuits	250 x I_N (one half cycle)
In the CT circuit for high sensitive earth-fault protection (refer to ordering code)	
Auxiliary voltage	
Rated voltage	24 to 48 V DC 60 to 125 V DC 1) 110 to 250 V DC 1) and 115 V AC with 50/60 Hz 1)
Permissible tolerance	-20 % to +20 %
Max. superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption	
During normal operation	Approx. 8 W
During pickup with all inputs and outputs activated	Approx. 18 W
Bridging time during auxiliary voltage failure V_{aux} 110 V	≥ 50 ms
Binary inputs	
Quantity Function can be assigned	8 or 16 or 24
Minimum permissible voltage Range is selectable with jumpers for each binary input	17 or 73 or 154 V DC, bipolar (3 operating ranges)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Output relays	
Quantity Function can be assigned	16 or 24 or 32
Switching capacity	
Make	1000 W /VA
Break	30 VA
Break (for resistive load)	40 W
Break (for $\tau = L/R \leq 50$ ms)	25 VA
Switching voltage	250 V
Permissible current	30 A for 0.5 s 5 A continuous

1) Ranges are settable by means of jumpers.

2) In course of preparation.

LEDs	
	Quantity
RUN (green)	1
ERROR (red)	1
Indication (red), function can be assigned	14
Unit design	
Housing 7XP20 1/2 x 19″ or 1/1 x 19″	See dimension drawings, part 16
Degree of protection acc. to EN 60529	
Surface-mounting housing	IP 51
Flush-mounting housing	
Rear	IP 50
Front	IP 51
For the terminals	IP 20 with terminal cover put on
Weight	
Flush-mounting housing	
1/2 x 19″	6 kg
1/1 x 19″	10 kg
Surface-mounting housing	
1/2 x 19″	11 kg
1/1 x 19″	19 kg

Serial interfaces (front of unit)	
Operating interface 1 for DIGSI 4 or browser	
Connection	Front panel, non-isolated, RS232, 9-pin subminiature connector
Baud rate	4800 to 115200 baud
Time synchronization (rear of unit)	
IRIG-B/DCF77/SCADA or 1 sec pulse from GPS (format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D)
Voltage levels	5 or 12 or 24 V
Service interface (operating interface 2) for DIGSI 4 / modem / service	
Isolated RS232/RS485	9-pin subminiature connector
Dielectric test	500 V/ 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485, depends on the baud rate	Max. 1000 m
Fiber-optic	Integrated ST connector
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	Max. 1.5 km
System interface	
(refer to ordering code)	IEC 60870-5-103 PROFIBUS-FMS PROFIBUS-DP DNP 3.0 IEC 61850 Ethernet 2)
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 38400 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m

Technical data

System interface, continued	
PROFIBUS RS485	
Dielectric test	500 V/50 Hz
Baud rate	Max. 12 Mbaud
Distance	1 km at 93.75 kB; 100 m at 12 MB
PROFIBUS fiber-optic[2]	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[2]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	500 kB/s 1.6 km, 1500 kB/s 530 m
Protection data interface (R2R interface)	
FO5[1], OMA1[2]: Fiber-optic interface with clock recovery for direct connection up to 1.5 km or for connection to a communication converter, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 8 dB
FO6[1], OMA2[2]: Fiber-optic interface for direct connection up to 3.5 km, 820 nm	For multi-mode fiber 62.5/125 µm, ST connectors Permissible fiber attenuation 16 dB
New fiber-optic interfaces, series FO1x	
FO17[1]: for direct connection up to 24 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 13 dB
FO18[1]: for direct connection up to 60 km[3], 1300 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB
FO19[1]: for direct connection up to 100 km[3], 1550 nm	For mono-mode fiber 9/125 µm, LC-Duplex connector Permissible fiber attenuation 29 dB
Relay communication equipment	
External communication converter 7XV5662-0AA00 for communication networks	
External communication converter to interface between the relays, optical 820 nm interface and the X21(RS422) G703.1 interface of a communication device	
X21/G703, RS422 selectable by jumpers. Baud rate selectable by jumpers	
Input: fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable to device side
Output: X21 (RS422) electrical interface on communication device	64/128/512 kbit (selectable by jumper) max. 800 m, 15-pin connector
G703.1 electrical interface on communication device	64 kbit/s, max. 800 m, screw-type terminal
External communication converter 7XV5662-0AC00 for pilot wires	
External communication converter to interface between relays, optical 820 nm interface and a pilot wire or twisted telephone pair.	
Typical distance	15 km
Fiber-optic 820 nm with clock recovery	Max. 1.5 km with 62.5/125 µm multi-mode FO cable
Pilot wire	Screw-type terminal 5 kV isolated
<u>Permissible time delay (duration of data transmission)</u>	
Delay of telegrams due to transmission for one unit to the other. Delay is constantly measured and adjusted	Max. 30 ms per transmission path Permissible max. value can be selected

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 For further standards see “Individual functions”
Insulation tests	
Standards	IEC 60255-5
Voltage test (100 % test)	
All circuits except for auxiliary supply, binary inputs and communication interfaces	2.5 kV (r.m.s.), 50/60 Hz
Auxiliary voltage and binary inputs (100 % test)	3.5 kV DC
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50/60 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for noise immunity; type tests	
Standards	IEC 60255-6, IEC 60255-22 (product standards) (type tests) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz

1) For flush-mounting housing.
2) For surface-mounting housing.
3) For surface-mounting housing the internal FO module OMA1 will be delivered together with an external repeater.

Technical data

Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min
High-energy surge voltages (SURGE) IEC 61000-4-5, installation class III	
Auxiliary supply	Common mode: 2 kV, 12 Ω, 9 µF Differential mode: 1 kV; 2 Ω, 18 µF
Measurements inputs, binary inputs, binary outputs	Common mode: 2 kV, 42 Ω, 0.5 µF Differential mode: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz; 0.5 mT; 50 MHz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz Damped wave; 50 surges per second; Duration 2 s; $R_i = 150\ \Omega$ to $200\ \Omega$
Fast transient surge withstand capability, ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s; $R_i = 80\ \Omega$
Radiated electromagnetic interference, IEEE C37.90.2	35 V/m; 25 to 1000 MHz amplitude and pulse-modulated
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz 1, 10 and 50 MHz, $R_i = 200\ \Omega$
EMC tests for interference emission; *type tests*	
Standard	EN 50081-* (generic standard)
Conducted interference voltage on lines, only auxiliary supply, IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical dynamic tests

Vibration, shock stress and seismic vibration

<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 othogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis), 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis), 8 to 35 Hz: 1 *g* acceleration (horizontal axis), 8 to 35 Hz: 0.5 *g* acceleration (vertical axis), frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes

1) Ordering option with high-speed contacts required.

<u>During transport</u>	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60255-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks each in both directions of the 3 axes

Climatic stress tests

Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity stress It is recommended to arrange the units in such a way, that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Yearly average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; condensation is not permitted

Functions

Differential protection *(ANSI 87L, 87T)*	
<u>Sensitive normal trip stage $I_{Diff}>$</u>	
Setting range of $I_{Diff}>$ secondary 1 A secondary 5 A	 0.1 to 20 A (step 0.1) 0.5 to 100 A
Tripping time (three line ends) $I_{Diff} > 2.5 \times I_{Diff} >$ (setting)	50 Hz Min. 27 ms Typ. 29 ms 60 Hz Min. 24 ms Typ. 26 ms
<u>Delay time of $I_{Diff}>$ trip stage</u>	
Delay time	0 to 60 s (step 0.01 s)
<u>Capacitive current load compensation</u>	
Restraint ratio $I_{C\ STAB} / I_{CN}$	 2 to 4 (steps 0.1)
<u>High-set fast trip stage $I_{Diff}>>$</u>	
Setting range $I_{Diff}>>$ secondary 1 A secondary 5 A	 0.8 to 100 A (step 0.1) 4 to 500 A (step 0.5)
Tripping time (three line ends) $I_{Diff} \geq 2.5 \times I_{Diff}>>$ (setting)	Min. 9 ms[1)] Typ. 12 ms[1)]

Technical data

Vector group adaptation with transformers in the differential zone	
Adaptation of connection symbol	0 to 11 (x 30 °) (step 1)
Neutral point connection	Grounded (earthed) or not grounded (earthed) (for each winding)
Inrush restraint	
Restraint ratio 2nd harmonic I_{2fN}/I_{fN}	 10 % to 45 % (step 1 %)
Max. current for restraint	1.1 A to 25 A[1)] (step 0.1 A)
Crossblock function	Can be switched on and off
Max. operative time for crossblock $T_{oper\ crossblk}$	0 to 60 s (step 0.01 s) or deactivated (operating up to release)
***Thermal overload protection** (ANSI 49)*	
Setting ranges Factor k acc. to IEC 60255-8 Time constant τ	 1 to 4 (steps 0.01) 1 to 999.9 min (steps 0.1 min)
Temperature alarm stage $\Theta_{alarm}/\Theta_{trip}$	50 to 100 % in relation to the trip temperature
Current alarm stage I_{alarm} Secondary 1 A Secondary 5 A	 0.1 to 4 A (step 0.1) 0.5 to 20 A (step 0.1)
Trip time characteristic	$t = \tau \ln \dfrac{I^2 - I_{pre}^2}{I^2 - (k \cdot I_N)^2}$
Reset ratios Θ / Θ_{alarm} Θ / Θ_{trip} I / I_{alarm}	 Approx. 0.99 Approx. 0.99
Tolerances	Class 10 % acc. to IEC
***Distance protection** (ANSI 21, 21N)*	
Distance protection zones	6, 1 of which as controlled zone, all zones can be set forward or/and reverse
Time stages for tripping delay Setting range	6 for multi-phase faults 3 for single-phase faults 0 to 30 s or deactivated (steps 0.01 s)
Characteristic Selectable separately for phase and ground (earth) faults	(refer to ordering code) quadrilateral and/or Mho (only impedance pickup)
Types of pickup	Overcurrent pickup (I>); Voltage-dependent overcurrent pickup (V< / I>); Voltage-dependent and phase angle-dependent overcurrent pickup (V< / I> / φ>); Impedance pickup (Z<)
Types of tripping	Three-pole for all types of faults; Single-pole for single-phase faults / otherwise three-pole; Single-pole for single-phase faults and two-pole phase-to-phase faults / otherwise three-pole
Time range	0 to 30 s (step 0.01 s) or deactivated
Line angle φ_L	30 ° to 89 ° (step 1 °)
Inclination angle for quadrilateral characteristic	30° to 90° (step 1°)
Quadrilateral reactance reach X	0.05 to 600 Ω(1A) / 0.01 to 120 Ω(5A) (step 0.001 Ω)
Quadrilateral resistance reach R for phase-to-phase faults and phase-to-ground(earth) faults	 0.05 to 600 Ω(1A) / 0.01 to 120 Ω(5A) (step 0.001Ω)

Mho impedance reach ZR	0.05 to 200 Ω(1A) / 0.01 to 40 Ω(5A) (step 0.01 Ω)
Minimum phase current I	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Overcurrent pickup I>> (for I>>, V</I>, V</I>/φ>)	0.25 to 10 A (1A) / 1.25 to 50 A (5A) (step 0.01 A)
Minimum current pickup I> (for V</I>, V</I>/φ> and Z<)	0.05 to 4 A (1A) / 0.25 to 20 A (5A) (step 0.01 A)
Minimum current pickup I_{φ}> (for V</I>, V</I>/φ>)	0.1 to 8 A (1A) / 0.5 to 40 A (5A) (step 0.01 A)
Undervoltage pickup (for V</I> and V</I>/φ>) V_{ph-e}< V_{ph-ph}<	 20 to 70 V (step 1 V) 40 to 130 V (step 1 V)
Load angle pickup (for V</I>/φ>) Load angle φ Load angle φ	 30 ° to 80 ° 90 ° to 120 °
Ground(earth)-fault pickup Neutral (residual) current $3I_0$ (Ground current)	 0.05 to 4 A (1A)/ 0.25 to 20 A (5A) (step 0.01 A)
Zero-sequence voltage $3V_0$> for earthed networks for resonant-earthed networks	 1 to 100 V (step 1 V) or deactivated 10 to 200 V (step 1 V)
Zero-sequence compensation Selectable input formats	 R_E/R_L and X_E/X_L k_0 and $\varphi(k_0)$
Separately selectable for zones	Z1 higher zones (Z1B, Z2 to Z5)
R_E/R_L and X_E/X_L	-0.33 to 7 (step 0.01)
k_0 $\varphi(k_0)$	0 to 4 (step 0.001) -135 to 135 ° (step 0.01 °)
Parallel line mutual compensation R_M/R_L and X_M/X_L	(refer to ordering code) 0.00 to 8 (step 0.01)
Phase reference on double earth-faults in resonant-earthed/ non-earthed network	Phase preference or no preference (selectable)
Load encroachment Minimum load resistance	 0.10 to 600 Ω(1A) / 0.02 to 120 Ω(5A) (step 0.001 Ω) or deactivated
Maximum load angle	20 to 60 ° (step 1 °)
Directional decision for all types of faults Directional sensitivity	With sound phase polarization and/or voltage memory Dynamically unlimited
Tolerances Impedances (in conformity with DIN 57435, Part 303)	For sinusodial quantities $\left\lvert\frac{\Delta X}{X}\right\rvert \le 5\,\%$ for $30° \le \varphi_{SC} \le 90°$ $\left\lvert\frac{\Delta R}{R}\right\rvert \le 5\,\%$ for $0° \le \varphi_{SC} \le 60°$ $\left\lvert\frac{\Delta Z}{Z}\right\rvert \le 5\,\%$ for $-30° \le (\varphi_{SC} - \varphi_{line}) \le +30°$
Response values (in conformity with DIN 57435, Part 303) V and I Angle (φ)	 ≤ 5 % of setting value ≤ 3 °
Timer tolerance	± 1 % of set value or 10 ms

1) Secondary data for I_N = 1 A; with I_N = 5 A the values must be multiplied.

Technical data

Operating times	
Minimum trip time with fast relays	Approx. 17 ms at 50 Hz Approx. 15 ms at 60 Hz
Minimum trip time with high-speed relays	Approx. 12 ms at 50 Hz Approx. 10 ms at 60 Hz
Reset time	Approx. 30 ms
***Power swing detection** (ANSI 68, 68T)*	
Power swing detection principle	Measurement of the rate of impedance vector change and monitoring of the vector path
Max. detectable power swing frequency	Approx. 7 Hz
Operating modes	Power swing blocking and/or power swing tripping (out-of-step tripping)
Power swing blocking programs	All zones blocked Z1/Z1B blocked Z2 to Z5 blocked Z1, Z1B, Z2 blocked
Detection of faults during power swing blocking	Reset of power swing blocking for all types of faults
***Tele (pilot) protection for distance protection** (ANSI 85-21)*	
Modes of operation	PUTT (Z1B acceleration); DUTT PUTT (acceleration with pickup); POTT; Directional comparison; Reverse interlocking Pilot-wire comparison; Unblocking; Blocking
Additional functions	Echo function (refer to weak-infeed function) Transient blocking for schemes with measuring range extension
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2 and 3-end-lines
Direct transfer trip (DTT)	
Direct phase-selective tripping via binary input	Alternatively with or without auto-reclosure
Trip time delay	0 to 30 s (step 0.01 s) or deactivated
Timer tolerance	± 1 % of setting value or 10 ms
Backup overcurrent protection (ANSI 50N, 51N)	
Operating modes	Active only with loss of data connection and voltage or always active
Characteristics	3 definite-time stages / 1 inverse-time stage
***Definite-time stage** (ANSI 50, 50N)*	
Pickup definite time stage 1, phase current	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A) or deactivated
Pickup definite-time stage 1, neutral (residual) current	0.5 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) or deactivated
Pickup definite-time stage 2, phase current	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A) or deactivated
Pickup definite-time stage 2, neutral (residual) current	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) or deactivated
Pickup definite-time stage 3, phase current	0.1 to 25 A (1A) / 0.5 to 125 A (5A) (step 0.01 A) or deactivated
Pickup definite-time stage 3, neutral (residual) current	0.05 to 25 A (1A) / 0.25 to 125 A (5A) (step 0.01 A) or deactivated
Time delay for definite-time stages	0 to 30 s, (step 0.01 s) or deactivated

Tolerances	
Current pickup	≤ 3 % of set value or 1 % of I_N
Delay times	± 1 % of set value or 10 ms
Operating time	Approx. 25 ms
***Inverse-time stage** (ANSI 51, 51N)*	
Phase current pickup	0.1 to 4 A (1A) /0.5 to 20 A (5A) (step 0.01 A) or deactivated
Neutral (residual) current pickup	0.05 to 4 A (1A) /0.25 to 20 A (5A) (step 0.01 A) or deactivated
Characteristics	
Characteristics according to IEC 60255-3	Normal inverse Very inverse Extremely inverse Long time inverse
Time multiplier	T_p = 0.05 to 3 s (step 0.01 s) or deactivated
Pickup threshold	Approx. 1.1 x I / I_p
Reset threshold	Approx. 1.05 x I / I_p
Tolerances	
Operating time for 2 ≤I/I_p ≤ 20	≤ 5 % of setpoint ± 15 ms
Characteristics according to ANSI/IEEE	Inverse Short inverse Long inverse Moderately inverse Very inverse Extremely inverse Definite inverse
Time dial	0.5 to 15 (step 0.01) or deactivated
Pickup threshold	Approx. 1.1 x M
Reset threshold	Approx. 1.05 x M
Tolerances	
Operating time for 2 ≤ M ≤ 20	≤ 5 % of setpoint ± 15 ms
***Instantaneous high-speed switch-onto-fault overcurrent protection** (ANSI 50HS)*	
Operating mode	Active only after c.b. closing; instantaneous trip after pickup
Characteristic	2 definite-time stages
Pickup current I >>>	0.1 to 15 A (1A) /0.5 to 75 A (5A) (step 0.01 A) or deactivated
Pickup current I >>>>	1 to 25 A (1A)/5 to 125 A (5A) (step 0.01 A) or deactivated
Reset ratio	Approx. 0.95
Tolerances	< 3 % of set value or 1 % of I_N
***Directional ground (earth)-fault overcurrent protection for high-resistance faults in systems with earthed star point** (ANSI 50N, 51N, 67N)*	
Characteristic	3 definite-time stages / 1 inverse-time stage or 4 definite-time stages or 3 definite-time stages / 1 $V_{0invers.}$ stage
Phase selector	Permits 1-pole tripping for single-phase faults or 3-pole tripping for multi-phase faults
Inrush restraint	Selectable for every stage
Instantaneous trip after switch-onto-fault	Selectable for every stage
Influence of harmonics	
Stages 1 and 2 (I>>> and I>>)	3rd and higher harmonics are completely suppressed by digital filtering
Stages 3 and 4 (I> and inverse 4th stage)	2nd and higher harmonics are completely suppressed by digital filtering

7

Technical data

Definite-time stage *(ANSI 50N)*	
Pickup value $3I_0$>>>	0.5 to 25 A $_{(1A)}$ / 2.5 to 125 A $_{(5A)}$ (step 0.01 A)
Pickup value $3I_0$>>	0.2 to 25 A $_{(1A)}$ / 1 to 125 A $_{(5A)}$ (step 0.01 A)
Pickup value $3I_0$>	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A $_{(1A)}$ / 0.015 to 125 A $_{(5A)}$ (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Pickup value $3I_0$, 4th stage	0.05 to 25 A $_{(1A)}$ / 0.25 to 125 A $_{(5A)}$ (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7); 0.003 to 25 A $_{(1A)}$ / 0.015 to 125 A $_{(5A)}$ (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Time delay for definite-time stages	0 to 30 s (step 0.01 s) or deactivated
Tolerances	
Current pickup	≤ 3 % of setting value or 1 % I_N
Delay times	1 % of setting value or 10 ms
Command / pickup times $3I_0$>>> and $3I_0$>>	Approx. 30 ms
Command / pickup times $3I_0$> and $3I_0$, 4th stage	Approx. 40 ms
Inverse-time stage *(ANSI 51N)*	
Ground (earth)-current pickup $3I_{0P}$	0.05 to 4 A $_{(1A)}$ / 0.25 to 20 A $_{(5A)}$ (step 0.01 A) Neutral (residual) current transformer with normal sensitivity (refer to ordering data, position 7) 0.003 to 4 A $_{(1A)}$ / 0.015 to 20 A $_{(5A)}$ (step 0.001 A) Neutral (residual) current transformer with high sensitivity (refer to ordering data, position 7)
Tripping characteristics acc. to IEC 60255-3	Normal inverse; very inverse; extremely inverse; long inverse
ANSI/IEEE tripping characteristic (not for region DE, refer to ordering data, position 10)	Inverse; short inverse; long inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Inverse logarithmic tripping characteristics (not for regions DE and US, refer to ordering data, position 10)	$t = T_{3I0\,\mathrm{Pmax}} - T_{3I0\mathrm{P}} \cdot \ln \dfrac{3I0}{3I0_{\mathrm{p}}}$
Pickup threshold	1.1 to 4.0 x I/I_p (step 0.1 s)
Time multiplier for IEC T characteristics	T_p = 0.05 to 3 s (step 0.01 s)
Time multiplier for ANSI D characteristics	D_{I0P} = 0.5 to 15 s (step 0.01 s)
Pickup threshold	Approx. 1.1 x I/I_p (ANSI: I/I_p = M)
Inverse logarithmic pickup threshold	1.1 to 4.0 x I/I_{0P} (step 0.1)
Reset threshold	Approx. 1.05 x I/I_{0P} (ANSI: I/I_p = M)
Tolerance	
Operating time for 2 ≤ I/I_p ≤ 20	≤ 5 % of setpoint ± 15 ms

Zero-sequence voltage protection $V_{0inverse}$	
Tripping characteristic	$t = \dfrac{2\text{ s}}{\dfrac{V_0}{4} - V_{0\text{inv min}}}$
Direction decision *(ANSI 67N)*	
Measured signals for direction decision	$3I_0$ and $3V_0$ or $3I_0$ and $3V_0$ and I_Y (star point current of an earthed power transformer) or $3I_2$ and $3V_2$ (negative-sequence system) or zero-sequence power S_r or automatic selection of zero-sequence or negative-sequence quantities dependent on the magnitude of the component voltages
Min. zero-sequence voltage $3V_0$	0.5 to 10 V (step 0.1 V)
Min. current I_Y (of grounded (earthed) transformers)	0.05 to 1 A $_{(1A)}$ / 0.25 to 5 A $_{(5A)}$ (step 0.01 A)
Min. negative-sequence voltage $3V_2$	0.5 to 10 V (step 0.1 V)
Min. negative-sequence current $3I_2$	0.05 to 1 A $_{(1A)}$ / 0.25 to 5 A $_{(5A)}$ (step 0.01 A)
Inrush current blocking, *capable of being activated for each stage*	
Component of the 2nd harmonic	10 to 45 % of the fundamental (step 1 %)
Max. current, which cancels inrush current blocking	0.5 to 25 A $_{(1A)}$ / 2.5 to 125 A $_{(5A)}$ (step 0.01 A)
Tele (pilot) protection for directional ground(earth)-fault overcurrent protection *(ANSI 85-67N)*	
Operating modes	Directional comparison: Pickup Directional comparison: Blocking Directional comparison: Unblocking
Additional functions	Echo (see function "weak infeed"); transient blocking for schemes with parallel lines
Transmission and reception signals	Phase-selective signals available for maximum selectivity with single-pole tripping; signals for 2 and 3-end-lines
Weak-infeed protection with undervoltage *(ANSI 27WI)*	
Operating modes with carrier (signal) reception	Echo Echo and trip with undervoltage
Undervoltage phase – ground (earth)	2 to 70 V (step 1 V)
Time delay	0.00 to 30 s (step 0.01 s)
Echo impulse	0.00 to 30 s (step 0.01 s)
Tolerances	
Voltage threshold	≤ 5 % of set value or 0.5 V
Timer	± 1 % of set value or 10 ms
Fault locator	
Output of the distance to fault	X, R (secondary) in Ω X, R (primary) in Ω Distance in kilometers or in % of line length
Start of calculation	With trip, with reset of pickup, with binary input
Reactance per unit length	0.005 to 6.5 Ω/km$_{(1A)}$ / 0.001 to 1.3 Ω/km$_{(5A)}$ (step 0.0001 Ω/km)
Tolerance	For sinusoidal quantities ≤ 2.5 % line length for 30 ° ≤ φ_{SC} ≤ 90 ° and V_{SC}/V_{nom} > 0.1

Technical data

Voltage protection *(ANSI 59, 27)*	
Operating modes	Local tripping or only indication
Overvoltage protection	
Pickup values $V_{PH\text{-}Gnd}$>>, $V_{PH\text{-}Gnd}$> (phase-ground (earth) overvoltage)	1 to 170 V (step 0.1 V) or deactivated
Pickup values $V_{PH\text{-}PH}$>>, $V_{PH\text{-}PH}$> (phase-phase overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Pickup values $3V_0$>>, $3V_0$> ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V) or deactivated
Pickup values V_1>>, V_1> (positive-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Measured voltage	Local positive-sequence voltage or calculated remote positive-sequence voltage (compounding)
Pickup values V_2>>, V_2> (negative-sequence overvoltage)	2 to 220 V (step 0.1 V) or deactivated
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values $V_{PH\text{-}Gnd}$<<, $V_{PH\text{-}Gnd}$< (phase-ground (earth) undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Pickup values $V_{PH\text{-}PH}$<<, $V_{PH\text{-}PH}$< (phase-phase undervoltage)	1 to 175 V (step 0.1 V) or deactivated
Pickup values V_1<<, V_1< (positive-sequence undervoltage)	1 to 100 V (step 0.1 V) or deactivated
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio	1.05
Time delays	
Time delay for all over- and undervoltage stages	0 to 100 s (steps 0.01 s) or deactivated
Command / pickup time	Approx. 30 ms
Tolerances	
Voltage limit values	≤ 3 % of setting value or 0.5 V
Time stages	1 % of setting value or 10 ms
Frequency protection *(ANSI 81)*	
Number of frequency elements	4
Setting range	45.5 to 54.5 Hz (in steps of 0.01) at f_{nom} = 50 Hz 55.5 to 64.5 Hz (in steps of 0.01) at f_{nom} = 60 Hz
Delay times	0 to 600 s or ∞ (in steps of 0.01 s)
Operating voltage range	6 to 230 V (phase-to-ground (earth))
Pickup times	Approx. 80 ms
Dropout times	Approx. 80 ms
Hysteresis	Approx. 20 mHz
Dropout condition	Voltage = 0 V and current = 0 A
Tolerances	
Frequency	12 m Hz for V = 29 to 230 V
Delay times	1 % of the setting value or 10 ms

Breaker failure protection *(ANSI 50BF)*	
Number of stages	2
Pickup of current element	0.05 to 20 $A_{(1A)}$ / 0.25 to 100 $A_{(5A)}$ (step 0.01 A)
Time delays $T1_{1phase}$, $T1_{3phase}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Additional functions	End-fault protection CB pole discrepancy monitoring
Reset time	Approx. 15 ms, typical; 25 ms max.
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms
Auto-reclosure *(ANSI 79)*	
Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1 or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T_{1\text{-}ph}$, $T_{3\text{-}ph}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (step 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage	30 to 90 V (step 1 V)
Dead line	2 to 70 V (step 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 0.5 V
Synchro-check *(ANSI 25)*	
Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes	
with auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 60 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1 °)
Max. duration of synchronization	0.01 to 600 s (step 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (step 0.01 s)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 2 V

7

Technical data

Trip circuit supervision (ANSI 74TC)	
Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (step 1 s)

Additional functions	
Operational measured values	
Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase}; $3I_0$; $I_{Gnd\ sensitve}$; I_1; I_2; I_Y; 3_{I0PAR} 3 x I_{Diff}, 3 x I_{Stab}
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{Phase\text{-}Ground}$; 3 x $V_{Phase\text{-}Phase}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}, V_{COMP}
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % V_{nom}
Power with direction indication	*P, Q, S*
Tolerances	
P: for $\lvert\cos\varphi\rvert$ = 0.7 to 1 and V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
Q: for $\lvert\sin\varphi\rvert$ = 0.7 to 1 and V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
S: for V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1 %
Frequency Tolerance	*f* ≤ 20 mHz
Power factor	PF (cos φ)
Tolerance for $\lvert\cos\varphi\rvert$ = 0.7 to 1	Typical ≤ 3 %
Load impedances with directional indication	3 x $R_{Phase\text{-}Ground}$, $X_{Phase\text{-}Ground}$ 3 x $R_{Phase\text{-}Phase}$, $X_{Phase\text{-}Phase}$
Overload measured values	Θ/Θ_{Trip} L1; Θ/Θ_{Trip} L2; Θ/Θ_{Trip} L3; Θ/Θ_{Trip}
Long-term mean values	
Interval for derivation of mean value	15 min / 1 min; 15 min / 3 min; 15 min / 15 min
Synchronization instant	Every ¼ hour; every ½ hour; every hour
Values	3 x I_{Phase}; I_1; *P*; *P*+; *P*-; *Q*; *Q*+; *Q*–; *S*
Minimum/maximum memory	
Indication	Measured values with date and time
Resetting	Cyclically Via binary input Via the keyboard Via serial interface
Values Min./max. of measured values	3 x I_{Phase}; I_1; 3 x $V_{Phase\text{-}Ground}$; 3 x $V_{Phase\text{-}to\text{-}phase}$; $3V_0$; V_1; *P*+; *P*–; *Q*+; *Q*–; *S*; *f*; power factor (+); power factor (–)
Min./max. of mean values	3 x I_{Phase}; I_1; *P*; *Q*; *S*
Energy meters	
Four-quadrant meters	W_{P+}; $W_{P–}$; W_{Q+}; $W_{Q–}$
Tolerance for $\lvert\cos\varphi\rvert$ > 0.7 and *V* > 50 % V_{nom} and *I* > 50 % I_{nom}	5 %

Oscillographic fault recording	
Analog channels	3 x I_{Phase}, $3I_0$, $3I_{0\ PAR}$, $3I_{0\ Gnd\ sensitive}$, 3 x I_{Diff}, 3 x I_{Stab} 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}, V_x
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	40
Control	
Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys
Remote control	Control protection, DIGSI, pilot wires
Further additional functions	
Measurement supervision	Current sum Current symmetry Voltage sum Voltage symmetry Voltage phase sequence Fuse failure monitor
Annunciations Event logging Fault logging	 Buffer size 200 Storage of signals of the last 8 faults, buffer size 800
Switching statistics	Number of breaking operations per c.b. pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle 3-phase TRIP/CLOSE cycle per phase
Setting range Dead time for CB TRIP/CLOSE cycle	0.00 to 30 s (step 0.01 s) 0.00 to 30 s (step 0.01 s)
Commissioning support	Operational measured values Circuit-breaker test Read binary test Initiate binary inputs Set binary outputs Set serial interface outputs Lockout of a device Test mode ot the differential protection topology

Technical data

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

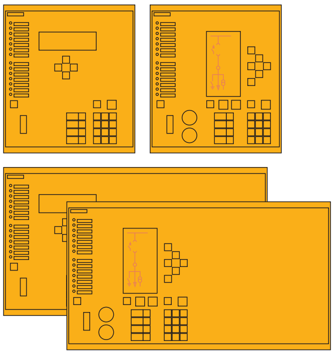
This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data



LSA4212en.eps

Operator panel with:
– function keys,
– numerical keys,
– PC interface
– display (pos. 5)
– key-operated switches (pos. 5)

Description	Order No.	Order code
7SD5 multi-end differential protection relay for two to six line ends	7SD5□□□-□□□□□-□□□□ □□□	
Operator panel options		
4-line backlit display	2	
Backlit graphic display, key-operated switch	3	
Relay type		
Multi-end differential prot. relay for two line end operation[1]	2	
Multi-end differential prot. relay for multi-line end op. (2 to 6)	3	
Measurement input		
I_{PH} = 1 A[2], I_{Gnd} = 1 A (min. = 0.05 A)	1	
I_{PH} = 1 A[2], I_{Gnd} = high sensitive (min. = 0.003 A)	2	
I_{PH} = 5 A[2], I_{Gnd} = 5 A (min. = 0.25 A)	5	
I_{PH} = 5 A[2], I_{Gnd} = high sensitive (min. = 0.003 A)	6	
Rated auxiliary voltage (power supply, binary indication voltage)		
24 to 48 V DC, binary input threshold 17 V[4]	2	
60 to 125 V DC[3], binary input threshold 17 V[4]	4	
110 to 250 V DC[3], 115 V AC, binary input threshold 73 V[4]	5	
220 to 250 V DC[3], 115 V AC, binary input threshold 154 V[4]	6	
Unit design / number of inputs and outputs		
1/2 x 19”, 8 BI, 16 BO, for flush mounting, with screw-type terminals	A	
1/1 x 19”, 16 BI, 24 BO, for flush mounting, with screw-type terminals	C	
1/1 x 19”, 24 BI, 32 BO, for flush mounting, with screw-type terminals	D	
1/2 x 19”, 8 BI, 16 BO, for surface mounting, with screw-type terminals	E	
1/1 x 19”, 16 BI, 24 BO, for surface mounting, with screw-type terminals	G	
1/1 x 19”, 24 BI, 32 BO, for surface mounting , with screw-type terminals	H	
1/2 x 19”, 8 BI, 16 BO, for flush mounting, with plug-in terminals	J	
1/1 x 19”, 16 BI, 24 BO, for flush mounting, with plug-in terminals	L	
1/1 x 19”, 24 BI, 32 BO, for flush mounting, with plug-in terminals	M	
With 5 high-speed trip contacts, approx. 1 ms closing time 1/1 x 19”, 16 BI, 24 BO, for flush mounting, with screw-type terminals	N	
With 5 high-speed trip contacts, approx. 1 ms 1/1 x 19”, 24 BI, 32 BO, for flush mounting, with screw-type terminals	P	
With 5 high-speed trip contacts, approx. 1 ms 1/1 x 19”, 16 BI, 24 BO, for surface mounting, with two-tier terminals	Q	
With 5 high-speed trip contacts, approx. 1 ms 1/1 x 19”, 24 BI, 32 BO, for surface mounting, with two-tier terminals	R	
With 5 high-speed trip contacts, approx. 1 ms 1/1 x 19”, 16 BI, 24 BO, for flush mounting, with plug-in terminals	S	
With 5 high-speed trip contacts, approx. 1 ms 1/1 x 19”, 24 BI, 32 BO, for flush mounting, with plug-in terminals	T	
Region and operating language		
Region DE, language German (selectable)	A	
Region World, language English (GB) (selectable)	B	
Region US, language English (US) (selectable)	C	
Region FR, language French (selectable)	D	
Region World, language Spanish (selectable)	E	

see next page

Regulation on region-specific presettings and function versions:

<u>Region DE:</u> preset to f = 50 Hz and line length in km, only IEC, directional ground-(earth) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r

<u>Region US:</u> preset to f = 60 Hz and line length in miles, ANSI inverse characteristic only, directional ground-(earth) fault protection: no logarithmic inverse characteristic, no direction decision with zero-sequence power S_r, no U_0 inverse characteristic

<u>Region World:</u> preset to f = 50 Hz and line length in km, directional ground-(earth) fault protection: no direction decision with zero-sequence S_r, no U_0 inverse characteristic

<u>Region FR:</u> preset to f = 50 Hz and line length in km, directional ground-(earth) fault protection: no U_0 inverse characteristic, no logarithmic inverse characteristic, weak infeed logic selectable between French specification and World specification

1) Hot standby with two protection data interfaces possible.
2) Rated current can be selected by means of jumpers.
3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
4) The binary input thresholds can be selected in two stages by means of jumpers.

7

Selection and ordering data

Description	Order No.	Order code
7SD5 multi-end differential protection relay for two to six line ends	7SD5□□□-□□□□□-□□□□	□□□
System interface: functionality and hardware		see next page
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, 820 nm optical, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485[1]	4	
PROFIBUS-FMS Slave, 820 nm optical, double ring, ST connector[1)2)]	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm optical, double ring, ST connector[2]	9	L 0 B
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm optical, ST connector[2]	9	L 0 H
DIGSI/modem interface (on rear side of unit) and protection interface	9	M□□
No DIGSI interface on rear of unit		0
DIGSI 4, electrical RS232		1
DIGSI 4, electrical RS485		2
DIGSI 4, fiber-optical 820 nm, ST connector		3
Protection data interface 1 (R2R interface)		
Optical 820 nm, two ST connectors, FO cable length up to 1.5 km for direct connection or via communication networks		A
Optical 820 nm, two ST connectors, FO cable length up to 3.5 km for direct connection via multi-mode FO cable		B
Optical 1300 nm, LC-Duplex connectors, FO cable length up to 24 km[3] for direct connection via mono-mode FO cable		G
Optical 1300 nm, LC-Duplex connectors, FO cable length up to 60 km[3] for direct connection via mono-mode FO cable		H
Optical 1550 nm, LC-Duplex connectors, FO cable length up to 100 km[3] for direct connection via mono-mode FO cable		J

1) For SICAM energy automation system.

2) Optical double ring interfaces are not available with surface-mounting housings. Please, order the version with RS485 interface and a separate electrical/ optical converter.

3) For surface-mounting housing applications, please select option A (820 nm, 1.5 km) together with an external repeater (for Order No., see Accessories).

Selection and ordering data

Description			Order No.	Order code
7SD5 multi-end differential protection relay for two to six line ends			7SD5□□□-□□□□□-□□□□	□□□

Functions 1

Trip mode	Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	
3-pole			0
3-pole	■		1
1/3-pole			2
1/3-pole	■		3
3-pole		■	4
3-pole	■	■	5
1/3-pole		■	6
1/3-pole	■	■	7

see next page

Functions 1 with protection interface 2 9 N□□

Functions 1

Trip mode	Auto-reclosure (ANSI 79)	Synchro-check (ANSI 25)	
3-pole			0
3-pole	■		1
1/3-pole			2
1/3-pole	■		3
3-pole		■	4
3-pole	■	■	5
1/3-pole		■	6
1/3-pole	■	■	7

Protection data interface 2 (R2R interface)

Optical 820 nm, two ST connectors, FO cable length up to 1.5 km for direct connection or via communication networks	A
Optical 820 nm, two ST connectors, FO cable length up to 3.5 km for direct connection via multi-mode FO cable	B
Optical 1300 nm, LC-Duplex connectors, FO cable length up to 24 km[1)] for direct connection via mono-mode FO cable	G
Optical 1300 nm, LC-Duplex connectors, FO cable length up to 60 km[1)] for direct connection via mono-mode FO cable	H
Optical 1550 nm, LC-Duplex connectors, FO cable length up to 100 km[1)] for direct connection via mono-mode FO cable	J

1) For surface-mounting applications, please select option A (820 nm, 1.5 km) together with an external repeater (for Order No., see Accessories).

Selection and ordering data

Description	Order No.	Order code
7SD5 multi-end differential protection relay for two to six line ends	7SD5□□□-□□□□□-□□□□ □□□	

Functions

Overcurrent time protection (ANSI 50, 50N, 51, 51N)	Breaker failure protection (ANSI 50BF)	Directional ground (earth)-fault protection, earthed networks (ANSI 50N, 51N, 67N)	Distance protection with quadrilateral and mho characteristic (ANSI 21, 21N)	Distance protection with special pickup methods (I>, V/I, V/I/φ, Z<) (ANSI 21, 21N)	Parallel line compensation	Power swing detection (ANSI 68, 68T)	
■	■						C
■	■			■	■	■	D
■	■		■		■	■	E
■	■	■					F
■	■	■		■	■	■	G
■	■	■	■		■	■	H

Additional function 1

4 remote commands 24 remote indications	Transformer extension with vector group adaption (ANSI 87T)	Fault locator with measurement at both line ends	Fault locator with measurement at 1 line end	Over/undervoltage protection V>, V< (ANSI 27,59) Over/underfrequency protection (ANSI 81)	
■			■		J
■			■	■	K
■		■	■		L
■		■	■	■	M
■	■		■		N
■	■		■	■	P
■	■	■	■		Q
■	■	■	■	■	R

Additional function 2

Measured values extended Min, max, mean	External GPS synchronization of differential protection	Capacitive charge current compensation	
			0
	■		1
■			2
■	■		3
		■	4
	■	■	5
■		■	6
■	■	■	7

Accessories

Description	Order No.
Opto-electric communication converter (connection to communication network)	
Converter to interface to X21 or G703.1 or RS422 synchronous communication interfaces. Connection via FO cable for 62.5 / 125 µm or 50 / 120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km Electrical connection via X21/RS422 or G703.1 interface	7XV5662-0AA00
Opto-electric communication converter (connection to pilot wire)	
Converter to interface to a pilot wire or twisted telephone pair (typical 15 km length) Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector; max. distance 1.5 km, screw-type terminals to pilot wire	7XV5662-0AC00
Opto-electric communication converter (ISDN connection)	
Converter to interface to an ISDN telephone line. Connection via FO cable for 62.5/125 µm or 50/120 µm and 820 nm wavelength (multi-mode FO cable) with ST connector, max. distance 1.5 km	7XV5662-0AB00
Additional interface modules	
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 1.5 km	C53207-A351-D651-1
Protection data interface mod. opt. 820 nm, multi-mode FO cable, ST connector, 3.5 km	C53207-A351-D652-1
Further modules	
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	C53207-A351-D655-1
Protection data interface mod. opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	C53207-A351-D656-1
Protection data interface mod. opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	C53207-A351-D657-1
Optical repeaters	
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 24 km	7XV5461-0BG00
Serial repeater (2-channel), opt. 1300 nm, mono-mode FO cable, LC-Duplex connector, 60 km	7XV5461-0BH00
Serial repeater (2-channel), opt. 1550 nm, mono-mode FO cable, LC-Duplex connector, 100 km	7XV5461-0BJ00
Time synchronizing unit with GPS output	
GPS 1 sec pulse and time telegram IRIG B/DCF 77	7XV5664-0AA00
Isolation transformer (20 kV) for pilot wire communication	7XR9516
Voltage transformer miniature circuit-breaker	
Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	3RV1611-1AG14

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows (Windows 2000 or XP Professional) device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows (Windows 2000 or XP Professional). Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
Manual for 7SD522/523 V4.3 English	C53000-G1176-C132

Fig. 7/68 Mounting rail for 19" rack

Fig. 7/69
2-pin connector

Fig. 7/70
3-pin connector

Fig. 7/71
Short-circuit link for current contacts

Fig. 7/72
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	C73334-A1-C35-1	1	Siemens	7/71
	3-pin	C73334-A1-C36-1	1	Siemens	7/72
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP [1]	
		0-827396-1	1	AMP [1]	
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP [1]	
		0-827397-1	1	AMP [1]	
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP [1]	
		0-163084-2	1	AMP [1]	
Crimping tool	For Type III+	0-539635-1	1	AMP [1]	
	and matching female	0-539668-2		AMP [1]	
	For CI2	0-734372-1	1	AMP [1]	
	and matching female	1-734387-1		AMP [1]	
19"-mounting rail		C73165-A63-D200-1	1	Siemens	7/70
Short-circuit links	For current terminals	C73334-A1-C33-1	1	Siemens	7/73
	For other terminals	C73334-A1-C34-1	1	Siemens	7/74
Safety cover for terminals	large	C73334-A1-C31-1	1	Siemens	
	small	C73334-A1-C32-1	1	Siemens	

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

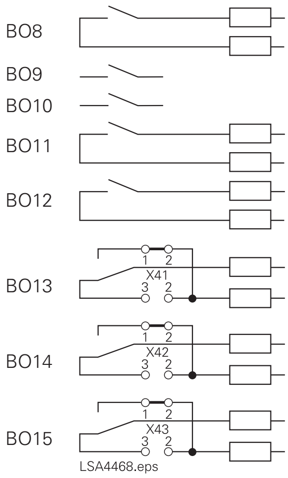


Fig.7/75

Additional setting by jumpers:

Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.

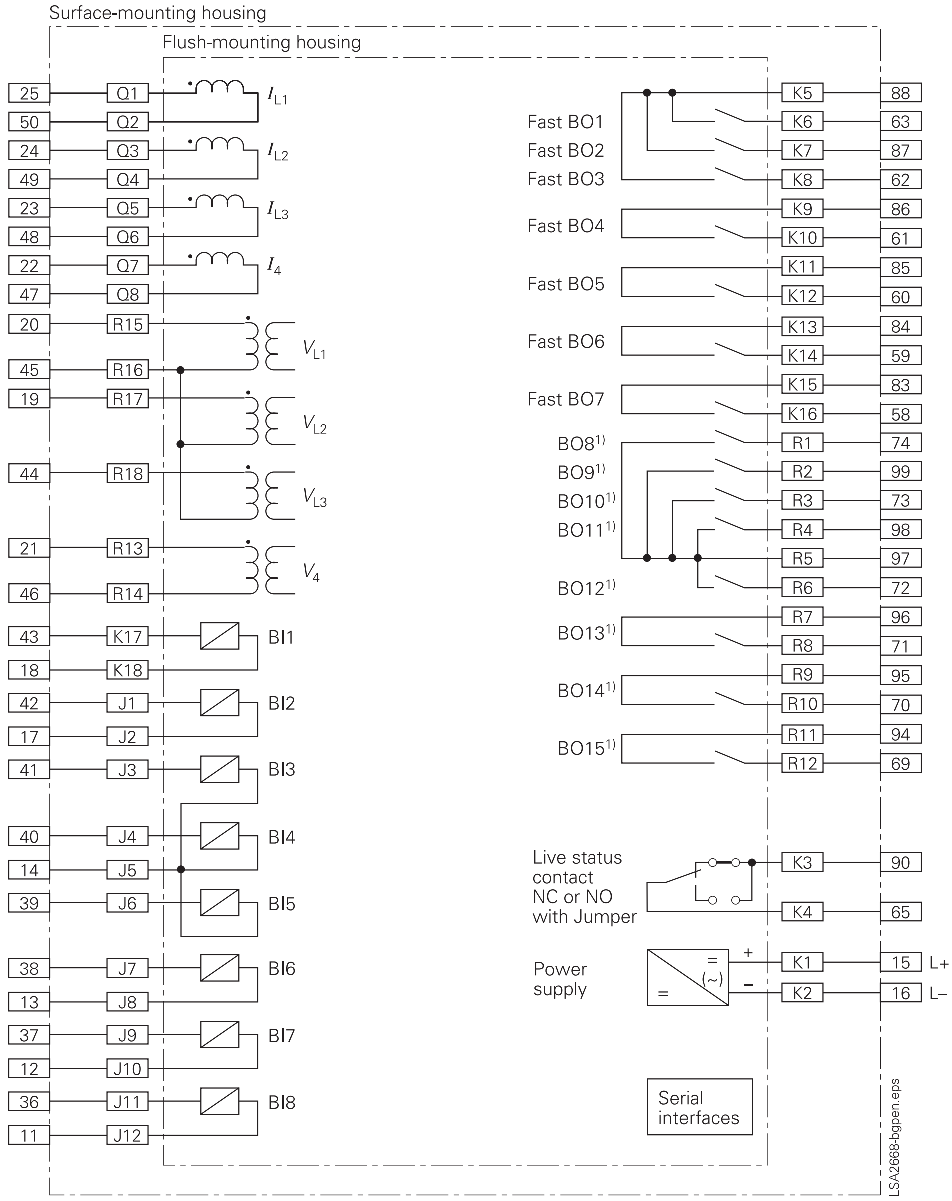


Fig. 7/73 Basic version in housing 1/2 x 19" with 8 binary inputs and 16 binary outputs

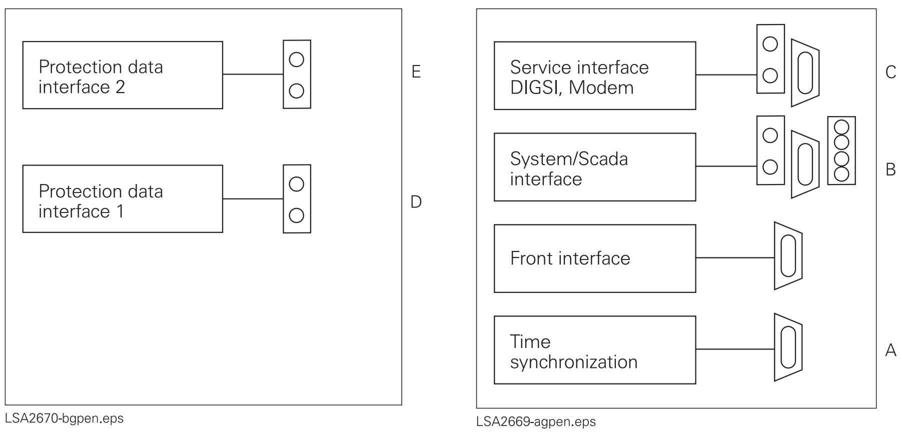


Fig. 7/74 Serial interfaces

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/75.

Connection diagram

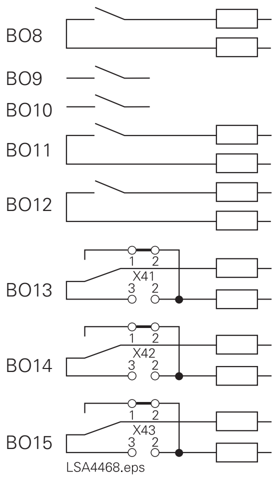


Fig.7/77

Additional setting by jumpers:

Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.

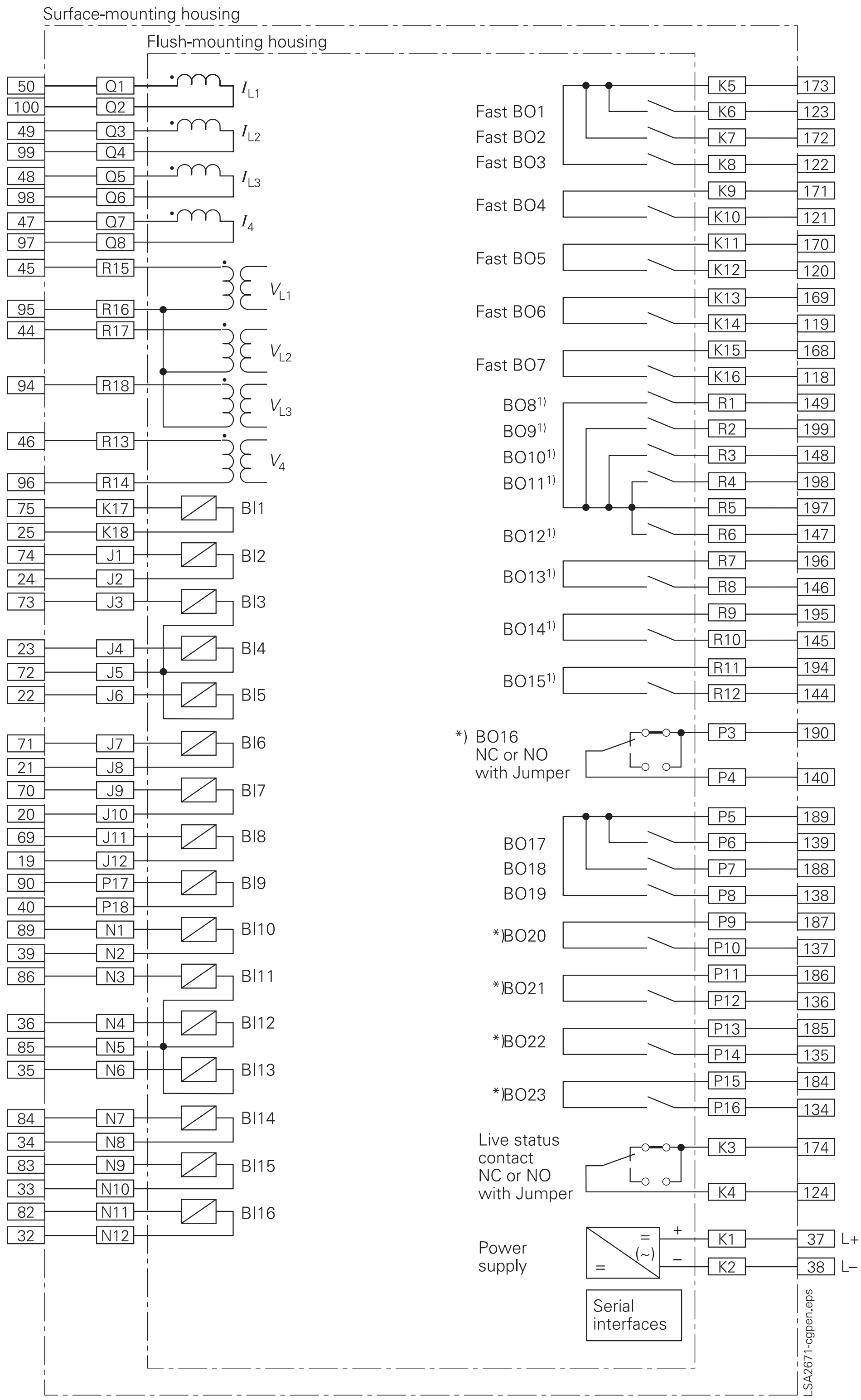


Fig. 7/76 Medium version in housing 1/1 x 19"

*) For unit version 7SD52xx-xN/S/Q high-speed contacts

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/78.

Connection diagram

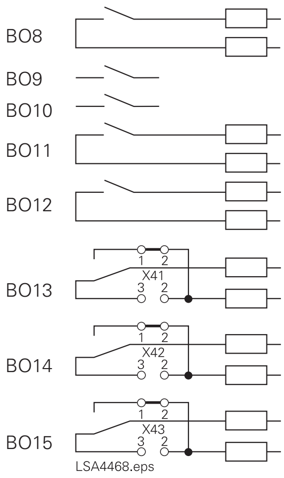


Fig.7/79

Additional setting by jumpers:

Separation of common circuit of BO8 to BO12 with jumpers X80, X81, X82. Switching of BO14, BO15 as NO contact or NC contact with jumpers X41, X42, X43.

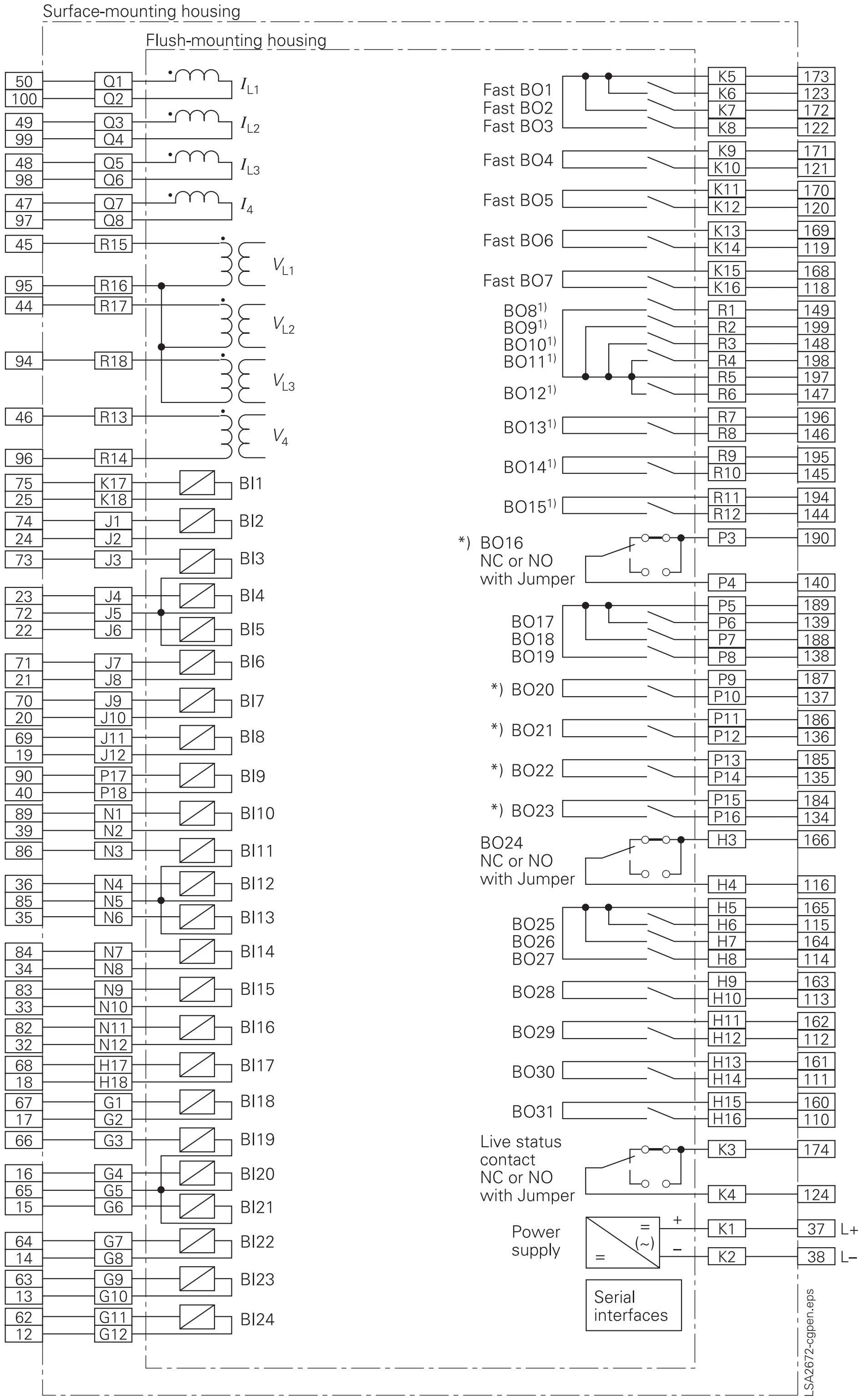


Fig. 7/78 Maximum version in housing 1/1 x 19"

*) For unit version 7SD52xx-xR/P/T high-speed contacts

1) Configuration of binary outputs until Hardware-version /EE. For advanced flexibility see Fig. 7/80.

Transformer Differential Protection

Page

SIPROTEC 4 7UT6 Differential Protection Relay for Transformers, Generators, Motors and Busbars

Fig. 8/1 SIPROTEC 4
7UT6 differential protection relay for transformers, generators, motors and busbars

Description

The SIPROTEC 7UT6 differential protection relays are used for fast and selective fault clearing of short-circuits in transformers of all voltage levels and also in rotating electric machines like motors and generators, for short lines and busbars.

The protection relay can be parameterized for use with three-phase and single-phase transformers.

The specific application can be chosen by parameterization. In this way an optimal adaptation of the relay to the protected object can be achieved.

In addition to the differential function, a backup overcurrent protection for 1 winding/star point is integrated in the relay. Optionally, a low or high-impedance restricted earth-fault protection, a negative-sequence protection and a breaker failure protection can be used. 7UT613 and 7UT633 feature 4 voltage inputs. With this option an overvoltage and undervoltage protection is available as well as frequency protection, reverse / forward power protection, fuse failure monitor and overexcitation protection. With external temperature monitoring boxes (thermo-boxes) temperatures can be measured and monitored in the relay. Therefore, complete thermal monitoring of a transformer is possible, e.g. hot-spot calculation of the oil temperature.

7UT613 and 7UT63x only feature full coverage of applications without external relays by the option of multiple protection functions e.g. overcurrent protection is available for each winding or measurement location of a transformer. Other functions are available twice: earth-fault differential protection, breaker failure protection and overload protection. Furthermore, up to 12 user-defined (flexible) protection functions may be activated by the customer with the choice of measured voltages, currents, power and frequency as input variables.

The relays provide easy-to-use local control and automation functions.
The integrated programmable logic (CFC) allows the users to implement their own functions, e.g. for the automation of switchgear (interlocking). User-defined messages can be generated as well.
The flexible communication interfaces are open for modem communication architectures with control system.

Function overview

- Differential protection for 2- up to 5-winding transformers (3-/1-phase)
- Differential protection for motors and generators
- Differential protection for short 2 up to 5 terminal lines
- Differential protection for busbars up to 12 feeders (phase-segregated or with summation CT)

Protection functions

- Differential protection with phase-segregated measurement
- Sensitive measuring for low-fault currents
- Fast tripping for high-fault currents
- Restraint against inrush of transformer
- Phase /earth overcurrent protection
- Overload protection with or without temperature measurement
- Negative-sequence protection
- Breaker failure protection
- Low/high-impedance restricted earth fault (REF)
- Voltage protection functions (7UT613/633)

Control functions

- Commands for control of circuit-breakers and isolators
- 7UT63x: Graphic display shows position of switching elements, local/remote switching by key-operated switch
- Control via keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined logic with CFC

Monitoring functions

- Self-supervision of the relay
- Trip circuit supervision
- Oscillographic fault recording
- Permanent differential and restraint current measurement, extensive scope of operational values

Communication interfaces

- PC front port for setting with DIGSI 4
- System interface
  IEC 61850 Ethernet
  IEC 60870-5-103 protocol,
  PROFIBUS-FMS/-DP,
  MODBUS or DNP 3.0
- Service interface for DIGSI 4 (modem)/ temperature monitoring (thermo-box)
- Time synchronization via IRIG-B/DCF 77

8

Application

The numerical protection relays 7UT6 are primarily applied as differential protection on

– transformers
  7UT612: 2 windings
  7UT613/633: 2 up to 3 windings
  7UT635: 2 up to 5 windings,
– generators
– motors
– short line sections
– small busbars
– parallel and series reactors.

The user selects the type of object that is to be protected by setting during configuration of the relay. Subsequently, only those parameters that are relevant for this particular protected object need to be set. This concept, whereby only those parameters relevant to a particular protected object need to be set, substantially contributed to a simplification of the setting procedure. Only a few parameters must be set. Therefore the new 7UT6 relays also make use of and extend this concept. Apart from the protected plant objects defined in the 7UT6, a further differential protection function allows the protection of

– single busbars with up to 12 feeders.

The well-proven differential measuring algorithm of the 7UT51 relay is also used in the new relays, so that a similar response with regard to short-circuit detection, tripping time saturation detection and inrush restraint is achieved.

8

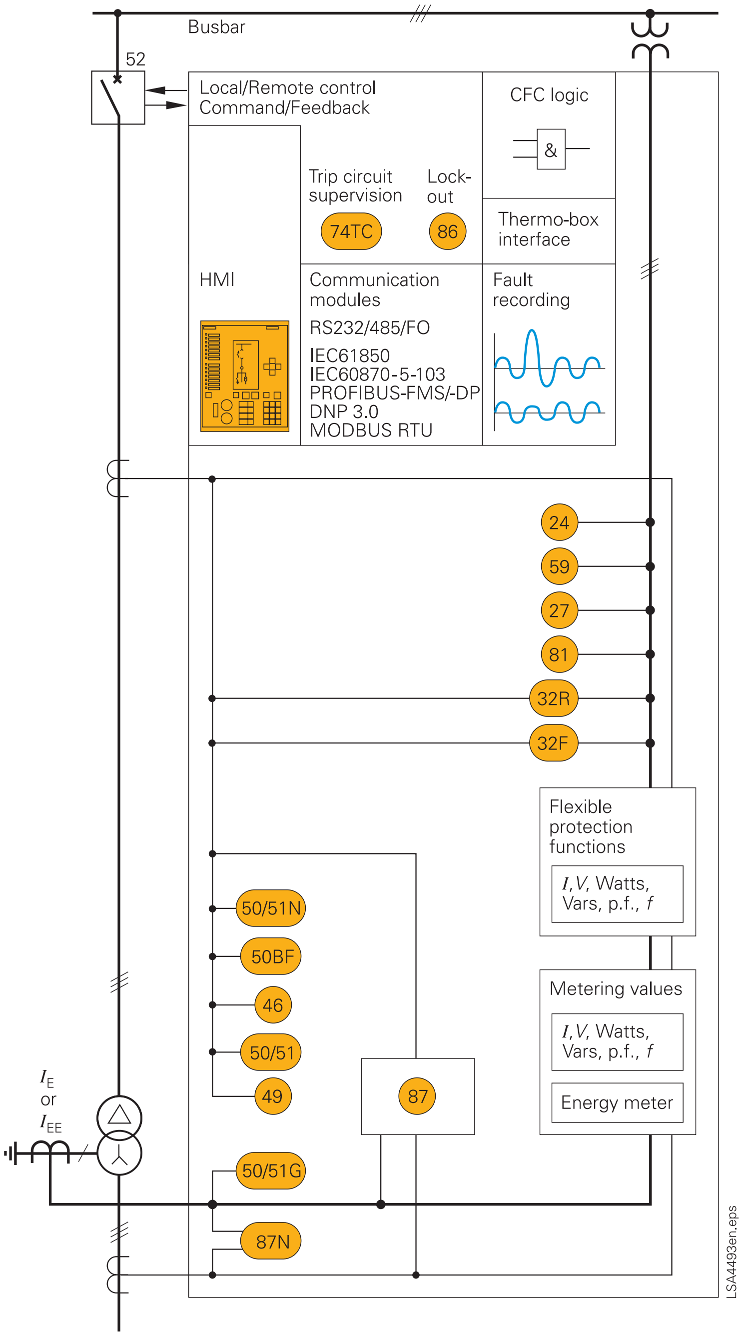


Fig. 8/2 Function diagram

Application

Protection functions	ANSI No.	7UT612	7UT613/33	7UT635	Three-phase transformer	Single-phase transformer	Auto-transformer	Generator/ Motor	Busbar, 3-phase	Busbar, 1-phase
Differential protection	87T/G/M/L	1	1	1	X	X	X	X	X	X
Earth-fault differential protection	87 N	1	2	2	X	X	X*)	X	–	–
Overcurrent-time protection, phases	50/51	1	3	3	X	X	X	X	X	–
Overcurrent-time protection $3I_0$	50/51N	1	3	3	X	–	X	X	X	–
Overcurrent-time protection, earth	50/51G	1	3	3	X	X	X	X	X	X
Overcurrent-time protection, single-phase		1	1	1	X	X	X	X	X	X
Negative-sequence protection	46	1	1	1	X	–	X	X	X	–
Overload protection IEC 60255-8	49	1	2	2	X	X	X	X	X	–
Overload protection IEC 60354	49	1	2	2	X	X	X	X	X	–
Overexcitation protection *) V/Hz	24	–	1	–	X	X	X	X	X	X
Overvoltage protection *) V>	59	–	1	–	X	X	X	X	–	–
Undervoltage protection *) V<	27	–	1	–	X	X	X	X	–	–
Frequency protection *) f>, f<	81	–	1	–	X	X	X	X	–	–
Reverse power protection *) -P	32R	–	1	–	X	X	X	X	–	–
Forward power protection*) P>, P<	32F	–	1	–	X	X	X	X	–	–
Fuse failure protection	60FL	–	1	–	X	X	X	X	–	–
Breaker failure protection	50 BF	1	2	2	X	X	X	X	X	–
External temperature monitoring (thermo-box)	38	X	X	X	X	X	X	X	X	X
Lockout	86	X	X	X	X	X	X	X	X	X
Measured-value supervision		X	X	X	X	X	X	X	X	X
Trip circuit supervision	74 TC	X	X	X	X	X	X	X	X	X
Direct coupling 1		X	X	X	X	X	X	X	X	X
Direct coupling 2		X	X	X	X	X	X	X	X	X
Operational measured values		X	X	X	X	X	X	X	X	X
Flexible protection functions	27, 32, 47, 50, 55, 59, 81	–	12	12	X	X	X	X	X	X

X Function applicable
– Function not applicable in this application
*) Only 7UT613/63x

Construction

The 7UT6 is available in three housing widths referred to a 19" module frame system. The height is 243 mm.

– 1/3 (7UT612),
– 1/2 (7UT613),
– 1/1 (7UT633/635) of 19"

All cables can be connected with or without cable ring lugs. Plug-in terminals are available as an option, it is thus possible to employ prefabricated cable harnesses. In the case of surface mounting on a panel, the connection terminals are located above and below in the form of screw-type terminals. The communication interfaces are located on the same sides of the housing. For dimensions please refer to the dimension drawings (part 16).

LSP2236F.tif

Fig. 8/3
Rear view with screw-type terminals

Protection functions

Differential protection for transformers (ANSI 87T)

When the 7UT6 is employed as fast and selective short-circuit protection for transformers the following properties apply:

- Tripping characteristic according to Fig. 8/4 with normal sensitive I_{DIFF}> and high-set trip stage I_{DIFF}>>
- Vector group and ratio adaptation
- Depending on the treatment of the transformer neutral point, zero-sequence current conditioning can be set with or without consideration of the neutral current. With the 7UT6, the star-point current at the star-point CT can be measured and considered in the vector group treatment, which increases sensitivity by one third for single-phase faults.
- Fast clearance of heavy internal transformer faults with high-set differential element I_{DIFF}>>.
- Restrain of inrush current with 2nd harmonic. Cross-block function that can be limited in time or switched off.
- Restrain against overfluxing with a choice of 3rd or 5th harmonic stabilization is only active up to a settable value for the fundamental component of the differential current.
- Additional restrain for an external fault with current transformer saturation (patented CT-saturation detector from 7UT51).
- Insensitivity to DC current and current transformer errors due to the freely programmable tripping characteristic and fundamental filtering.
- The differential protection function can be blocked externally by means of a binary input.

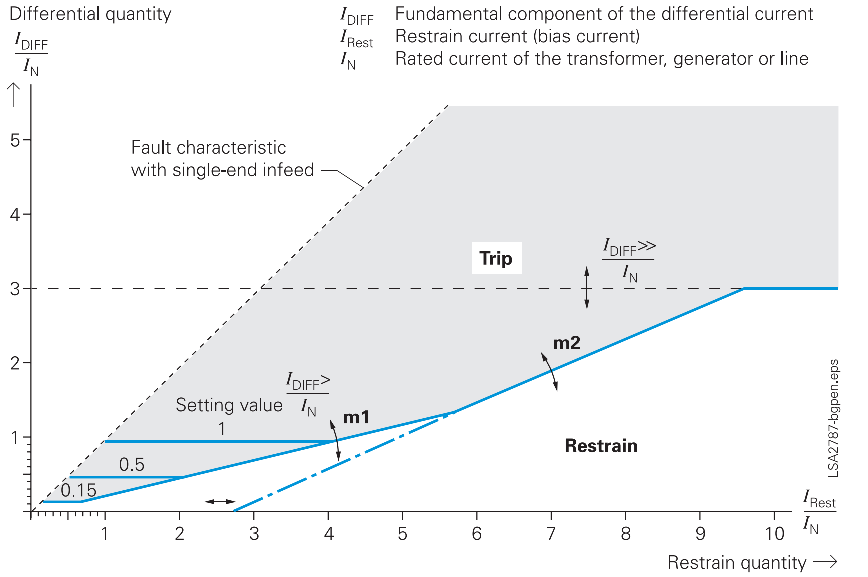


Fig. 8/4
Tripping characteristic with preset transformer parameters for three-phase faults

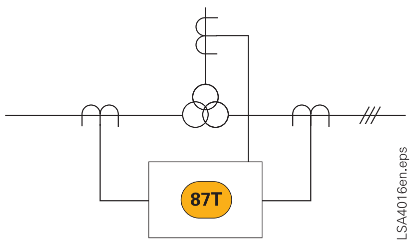


Fig. 8/5
3-winding transformers (1 or 3-phase)

Protection functions

Sensitive protection by measurement of star-point current (see Fig. 8/6) (ANSI 87N/87GD)

Apart from the current inputs for detection of the phase currents on the sides of the protected object, the 7UT6 also contains normal sensitivity I_E and high sensitivity I_{EE} current measuring inputs. Measurement of the star-point current of an earthed winding via the normal sensitivity measuring input, and consideration of this current by the differential protection, increases the sensitivity during internal single-phase faults by 33 %. If the sum of the phase currents of a winding is compared with the star-point current measured with the normal sensitivity input I_E, a sensitive earth current differential protection can be implemented (REF).

This function is substantially more sensitive than the differential protection during faults to earth in a winding, detecting fault currents as small as 10 % of the transformer rated current.

Furthermore, this relay contains a high-impedance differential protection input. The sum of the phase currents is compared with the star-point current. A voltage-dependent resistor (varistor) is applied in shunt (see Fig. 8/6). Via the sensitive current measuring input I_{EE}, the voltage across the varistor is measured; in the milli-amp range via the external resistor. The varistor and the resistor are mounted externally. An earth fault results in a voltage across the varistor that is larger than the voltage resulting from normal current transformer errors. A prerequisite is the application of accurate current transformers of the class 5P (TPY) which exhibit a small measuring error in the operational and overcurrent range. These current transformers may not be the same as used for the differential protection, as the varistor may cause rapid saturation of this current transformers.

Both high-impedance and low-impedance REF are each available twice (option) for transformers with two earthed windings. Thus separate REF relays are not required.

Differential protection for single-phase busbars (see Fig. 8/7) (ANSI 87L)

The short-circuit protection is characterized by the large number of current measuring inputs. The scope of busbar protection ranges from a few bays e.g. in conjunction with one and a half circuit-breaker applications, to large stations having up to more than 50 feeders. In particular in smaller stations, the busbar protection arrangements are too expensive. With the 7UT6 relays the current inputs may also be used to achieve a cost-effective busbar protection system for up to 12 feeders (Fig. 8/7). This busbar protection functions as a phase-selective protection with 1 or 5 A current transformers, whereby the protected phase is connected. All three phases can therefore be protected by applying three relays. Furthermore a single-phase protection can be implemented by connecting the three-phase currents via a summation transformer. The summation transformer connection has a rated current of 100 mA.

The selectivity of the protection can be improved by monitoring the current magnitude in all feeders, and only releasing the differential protection trip command when the overcurrent condition is also met. The security measures to prevent maloperation resulting from failures in the current transformer secondary circuits can be improved in this manner. This overcurrent release may also be used to implement a breaker failure protection. Should the release signal not reset within a settable time, this indicates that a breaker failure condition is present, as the short-circuit was not switched off by the bay circuit-breaker. After expiry of the time delay the circuit-breakers of the infeeds to the busbar may be tripped.

Differential protection for generators and motors (see Fig. 8/8) (ANSI 87G/M)

Equal conditions apply for generators, motors and series reactors. The protected zone is limited by the sets of current transformers at each side of the protected object.

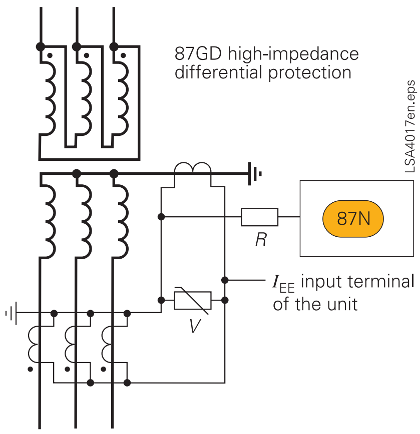


Fig. 8/6
High-impedance differential protection

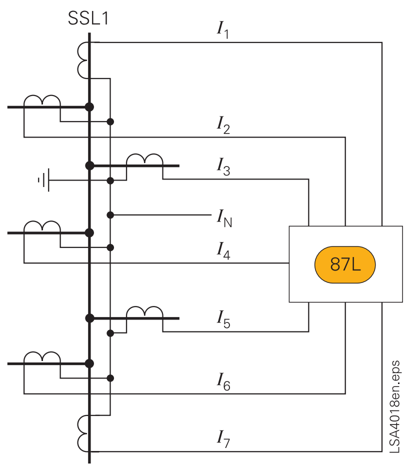


Fig. 8/7
Simple busbar protection with phase-selective configuration
7UT612: 7 feeders
7UT613/633: 9 feeders
7UT635: 12 feeders

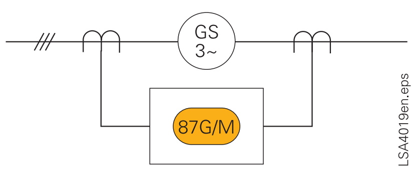


Fig. 8/8
Generator/motor differential protection

Protection functions

■ Backup protection functions

Overcurrent-time protection (ANSI 50, 50N, 51, 51N)

Backup protection on the transformer is achieved with a two-stage overcurrent protection for the phase currents and $3I_0$ for the calculated neutral current. This function may be configured for one of the sides or measurement locations of the protected object. The high-set stage is implemented as a definite-time stage, whereas the normal stage may have a definite-time or inverse-time characteristic. Optionally, IEC or ANSI characteristics may be selected for the inverse stage. The overcurrent protection $3I_0$ uses the calculated zero-sequence current of the configured side or measurement location.
Multiple availability: 3 times (option)

Overcurrent-time protection for earth (ANSI 50/51G)

The 7UT6 feature a separate 2-stage overcurrent-time protection for the earth. As an option, an inverse-time characteristic according to IEC or ANSI is available. In this way, it is possible to protect e.g. a resistor in the transformer star point against thermal overload, in the event of a single-phase short-circuit not being cleared within the time permitted by the thermal rating.
Multiple availability: 3 times (option)

Phase-balance current protection (ANSI 46) (Negative-sequence protection)

Furthermore a negative-sequence protection may be defined for one of the sides or measurement locations. This provides sensitive overcurrent protection in the event of asymmetrical faults in the transformer. The set pickup threshold may be smaller than the rated current.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected upon issuing of a trip command, another command can be initiated using the breaker failure protection which operates the circuit-breaker, e.g., of an upstream (higher-level) protection relay.
Multiple availability: 2 times (option)

Overexcitation protection Volt/Hertz (ANSI 24) (7UT613/633 only)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to V/f) in generators or transformers, which leads to a thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via seven points derived from the manufacturer data.
In addition, a definite-time alarm stage and an instantaneous stage can be used.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

External trip coupling

For recording and processing of external trip information via binary inputs. They are provided for information from the Buchholz relay or specific commands and act like a protective function. Each input initiates a fault event and can be individually delayed by a timer.

Undervoltage protection (ANSI 27) (7UT613/633 only)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.

The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59) (7UT613/633 only)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-earth voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by earth faults. This function is implemented in two stages.

Frequency protection (ANSI 81) (7UT613/633 only)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency. It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as underfrequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

Protection functions

Reverse-power protection (ANSI 32R) (7UT613/633 only)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails. This function can be used for operational shutdown (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical power system faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (±) of the active power can be reversed via parameters.

Forward-power protection (ANSI 32F) (7UT613/633 only)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors exceeding of a limit value, while another stage monitors falling below another limit value. The power is calculated using the positive-sequence component of current and voltage. The function can be used to shut down idling motors.

Flexible protection functions (7UT613/63x only)

For customer-specific solutions up to 12 flexible protection functions are available and can be parameterized. Voltages, currents, power and frequency from all measurement locations can be chosen as inputs. Each protection function has a settable threshold, delay time, blocking input and can be configured as a 1-phase or 3-phase unit.

Monitoring functions

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, battery, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions. (7UT613/633 only)

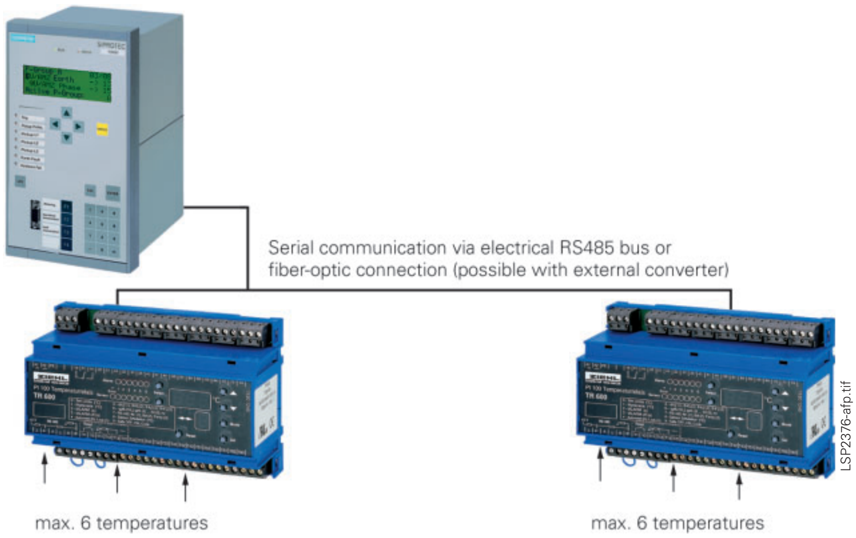


Fig. 8/9
Temperature measurement and monitoring with external thermo-boxes

Thermal monitoring of transformers

The importance of reducing the costs of transmitting and distributing energy by optimizing the system load has resulted in the increased importance of monitoring the thermal condition of transformers. This monitoring is one of the tasks of the monitoring systems, designed for medium and large transformers. Overload protection based on a simple thermal model, and using only the measured current for evaluation, has been integrated in differential protection systems for a number of years.

The ability of the 7UT6 to monitor the thermal condition can be improved by serial connection of a temperature monitoring box (also called thermo-box or RTD-box) (Fig. 8/9). The temperature of up to 12 measuring points (connection of 2 boxes) can be registered. The type of sensor (Pt100, Ni100, Ni120) can be selected individually for each measuring point. Two alarm stages are derived for each measuring point when the corresponding set threshold is exceeded.

Alternatively to the conventional overload protection, the relay can also provide a hot-spot calculation according to IEC 60345. The hot-spot calculation is carried out separately for each leg of the transformer and takes the different cooling modes of the transformer into consideration.

The oil temperature must be registered via the thermo-box for the implementation of this function. An alarm warning stage and final alarm stage is issued when the maximum hot-spot temperature of the three legs exceeds the threshold value.

For each transformer leg a relative rate of ageing, based on the ageing at 98 °C is indicated as a measured value. This value can be used to determine the thermal condition and the current thermal reserve of each transformer leg. Based on this rate of ageing, a remaining thermal reserve is indicated in % for the hottest spot before the alarm warning and final alarm stage is reached.

Protection functions

Measured values

The operational measured values and statistic value registering in the 7UT6, apart from the registration of phase currents and voltages (7UT613/633 only) as primary and secondary values, comprises the following:

- Currents 3-phase I_{L1}, I_{L2}, I_{L3}, I_1, I_2, $3I_0$ for each side and measurement location
- Currents 1-phase I_1 to I_{12} for each feeder and further inputs I_{x1} to I_{x4}
- Voltages 3-phase V_{L1}, V_{L2}, V_{L3}, V_{L1L2}, V_{L2L3}, V_{L3L1}, V_1, V_2, V_0 and 1-phase V_{EN}, V_4
- Phase angles of all 3-phase/ 1-phase currents and voltages
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase selective)
- Power factor ($\cos\varphi$),
- Frequency
- Energy $\pm$ kWh, $\pm$ kVarh, forward and reverse power flow
- Min./max. and mean values of V_{PH-PH}, V_{PHE}, V_E, V_0, V_1, V_2, I_{PH}, I_1, I_2, $3I_0$, I_{DIFF}, $I_{RESTRAINT}$, S, P, Q, $\cos\varphi$, f
- Operating hours counter
- Registration of the interrupted currents and counter for protection trip commands
- Mean operating temperature of overload function
- Measured temperatures of external thermo-boxes
- Differential and restraint currents of differential protection and REF

Metered values

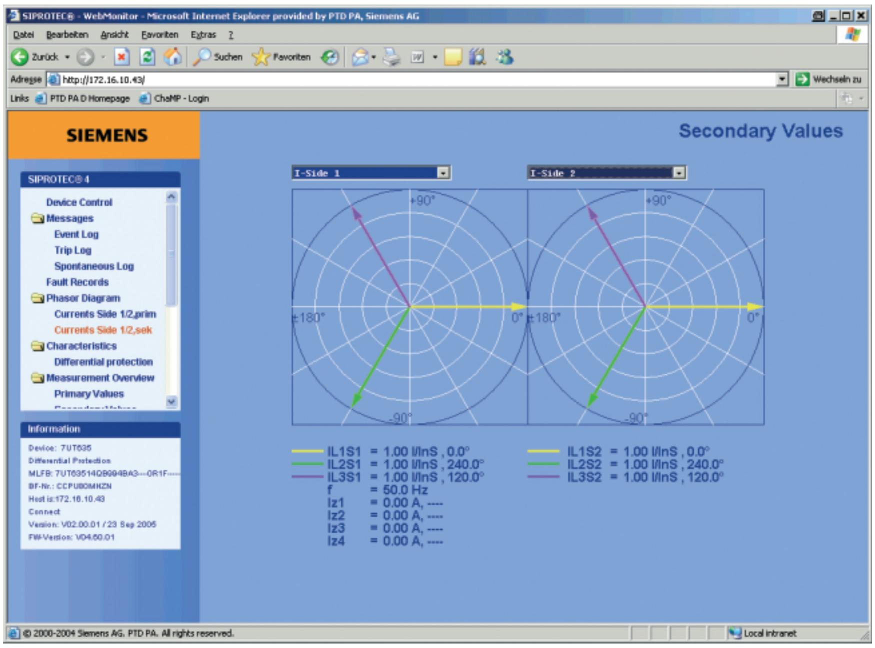
For internal metering, the unit can calculate an energy metered value from the measured current and voltage values.

The 7UT6 relays may be integrated into monitoring systems by means of the diverse communication options available in the relays. An example for this is the connection to the SITRAM transformer monitoring system with PROFIBUS-DP interface.

Commissioning and operating aids

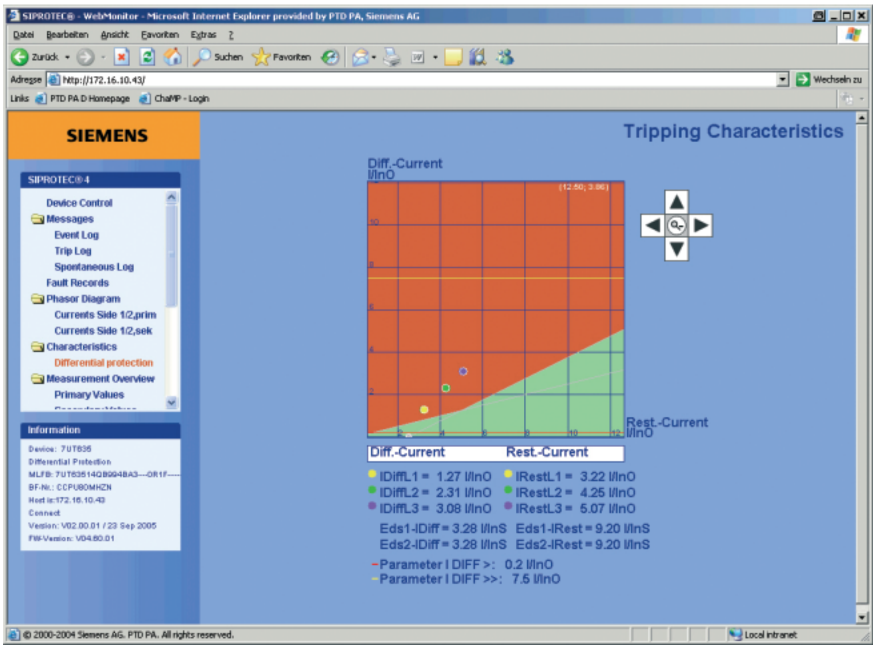
Commissioning could hardly be easier and is fully supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the bay controller. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the bay controller communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test marking for test purposes can be connected to a control and protection system.

All measured currents and voltages (7UT613/633 only) of the transformer can be indicated as primary or secondary values. The differential protection bases its pickup thresholds on the rated currents of the transformer. The referred differential and stabilising (restraint) currents are available as measured values per phase.
If a thermo-box is connected, registered temperature values may also be displayed.
To check the connection of the relay to the primary current and voltage transformers, a commissioning measurement is provided.



LSP2821.tif

Fig. 8/10
Commissioning via a standard Web browser: Phasor diagram



LSP2822.tif

Fig. 8/11
Commissioning via a standard Web browser: Operating characteristic

Protection functions

This measurement function works with only 5 to 10 % of the transformer rated current and indicates the current and the angle between the currents and voltages (if voltages applied). Termination errors between the primary current transfomers and input transformers of the relay are easily detected in this manner.

The operating state of the protection may therefore be checked online at any time. The fault records of the relay contain the phase and earth currents as well as the calculated differential and restraint currents. The fault records of the 7UT613/633 relays also contain voltages.

Browser-based commissioning aid

The 7UT6 provides a commissioning and test program which runs under a standard internet browser and is therefore independent of the configuration software provided by the manufacturer.

For example, the correct vector group of the transformer may be checked. These values may be displayed graphically as vector diagrams.

The stability check in the operating characteristic is available as well as event log and trip log messages. Remote control can be used if the local front panel cannot be accessed.

■ Control and automation functions

Control

In addition to the protection functions, the SIPROTEC 4 units also support all control and monitoring functions that are required for operating medium-voltage or high-voltage substations.

The main application is reliable control of switching and other processes.

The status of primary equipment or auxiliary devices can be obtained from auxiliary contacts and communicated via binary inputs. Therefore it is possible to detect and indicate both the OPEN and CLOSED position or a fault or intermediate circuit-breaker or auxiliary contact position.

The switchgear or circuit-breaker can be controlled via:

– integrated operator panel
– binary inputs
– substation control and protection system
– DIGSI 4

Command processing

All the functionality of command processing is offered. This includes the processing of single and double commands with or without feedback, sophisticated monitoring of the control hardware and software, checking of the external process, control actions using functions such as runtime monitoring and automatic command termination after output. Here are some typical applications:

- Single and double commands using 1, 1 plus 1 common or 2 trip contacts
- User-definable bay interlocks
- Operating sequences combining several switching operations such as control of circuit-breakers, disconnectors and earthing switches
- Triggering of switching operations, indications or alarm by combination with existing information

Automation / user-defined logic

With integrated logic, the user can set, via a graphic interface (CFC), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface.

Switching authority

Switching authority is determined according to parameters, communication or by key-operated switch (when available).

If a source is set to “LOCAL”, only local switching operations are possible. The following sequence of switching authority is laid down: “LOCAL”; DIGSI PC program, “REMOTE”

Every switching operation and change of breaker position is kept in the status indication memory. The switch command source, switching device, cause (i.e. spontaneous change or command) and result of a switching operation are retained.

Assignment of feedback to command

The positions of the circuit- breaker or switching devices and transformer taps are acquired by feedback. These indication inputs are logically assigned to the corresponding command outputs. The unit can therefore distinguish whether the indication change is a consequence of switching operation or whether it is a spontaneous change of state (intermediate position).

Chatter disable

The chatter disable feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the event list will not record excessive operations.

Filter time

All binary indications can be subjected to a filter time (indication suppression).

Indication filtering and delay

Indications can be filtered or delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time. In the event of indication delay, there is a wait for a preset time. The information is passed on only if the indication voltage is still present after this time.

Indication derivation

A further indication (or a command) can be derived from an existing indication. Group indications can also be formed. The volume of information to the system interface can thus be reduced and restricted to the most important signals.

Transmission lockout

A data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test operation

During commissioning, all indications can be passed to an automatic control system for test purposes.

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. Of particular advantage is the use of the DIGSI 4 operating program during commissioning.

Rear-mounted interfaces

Two communication modules located on the rear of the unit incorporate optional equipment complements and readily permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces.

The interfaces make provision for the following applications:

- Service interface (Port C/Port D[1])
  In the RS485 version, several protection units can be centrally operated with DIGSI 4. On connection of a modem, remote control is possible. Via this interface communication with thermo-boxes is executed.
- System interface (Port B)
  This interface is used to carry out communication with a control or protection and control system and supports a variety of communication protocols and interface designs, depending on the module connected.

Commissioning aid via a standard Web browser

In the case of the 7UT6, a PC with a standard browser can be connected to the local PC interface or to the service interface (refer to “Commissioning program”). The relays include a small Web server and send their HTML-pages to the browser via an established dial-up network connection.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 unit range. These ensure that, where different communication interfaces (electrical or optical) and protocols (IEC 61850 Ethernet, IEC 60870-5-103, PROFIBUS-FMS/-DP, MODBUS RTU, DNP 3.0, DIGSI, etc.) are required, such demands can be met.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors electromagnetic fault influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any disturbances.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

It is generally impossible to communicate with a unit that has failed. If a unit were to fail, there is no effect on the communication with the rest of the system.

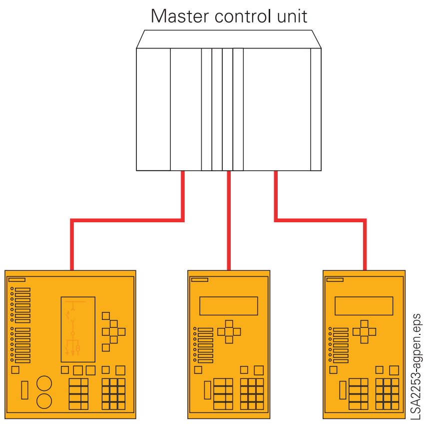


Fig. 8/12
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

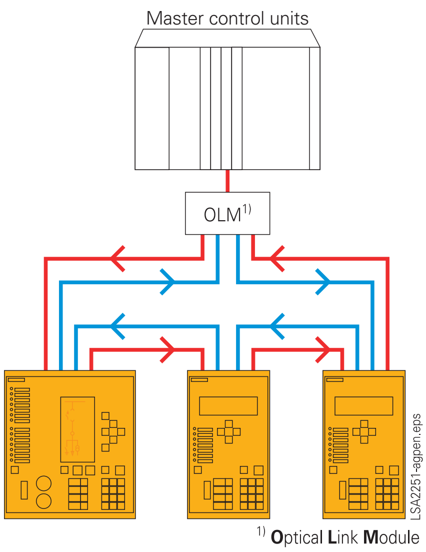


Fig. 8/13
Bus structure: Fiber-optic double ring circuit

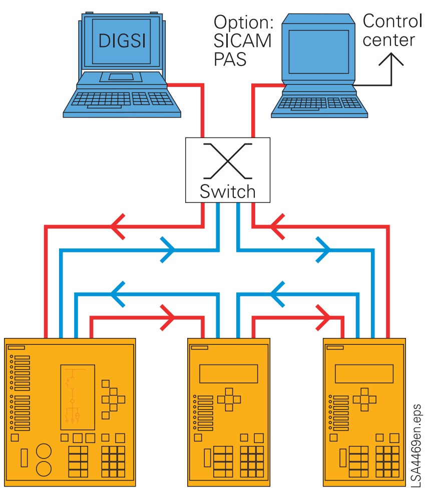


Fig. 8/14
Bus structure for station bus with Ethernet und IEC 61850, fiber-optic ring

1) Only for 7UT613/633/635

Communication

IEC 61850 Ethernet

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus is also possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for the efficient communication in the protected area.
IEC 60870-5-103 is supported by a number of protection device manufacturers and is used worldwide.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized communication system (EN 50170). PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world.

Connection to a SIMATIC S5/S7 programmable controller is made on the basis of the data obtained (e.g. fault recording, fault data, measured values and control functionality) via SICAM energy automation system or via PROFIBUS-DP.

PROFIBUS-DP

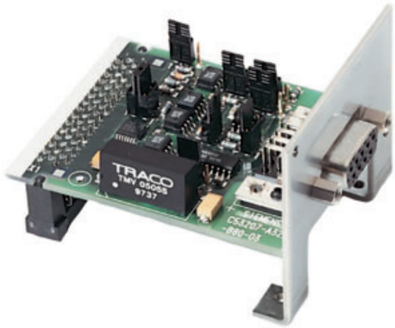
PROFIBUS-DP is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

MODBUS RTU

MODBUS RTU is an industry-recognized standard for communications and is supported by a number of PLC and protection device manufacturers.

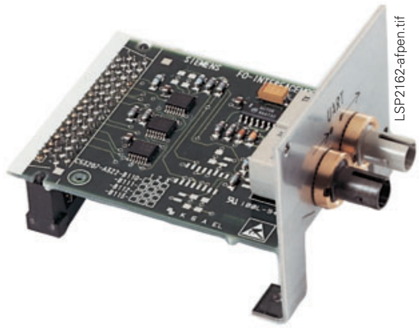
DNP 3.0

DNP 3.0 (Distributed Network Protocol Version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0.
DNP 3.0 is supported by a number of protection device manufacturers.



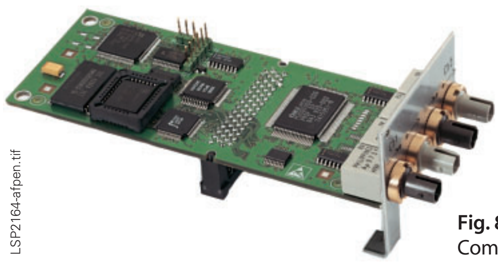
LSP2163-afpen.tif

Fig. 8/15
R232/RS485 electrical communication module



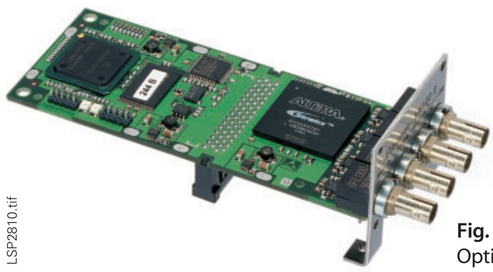
LSP2162-afpen.tif

Fig. 8/16
Fiber-optic communication module



LSP2164-afpen.tif

Fig. 8/17
Communication module, optical double-ring



LSP2810.tif

Fig. 8/18
Optical Ethernet communication module for IEC 61850 with integrated Ethernet switch

Communication

System solutions for protection and station control

Together with the SICAM power automation system, SIPROTEC 4 can be used with PROFIBUS-FMS. Over the low-cost electrical RS485 bus, or interference-free via the optical double ring, the units exchange information with the control system.

Units featuring IEC 60870-5-103 interfaces can be connected to SICAM in parallel via the RS485 bus or radially by fiber-optic link. Through this interface, the system is open for the connection of units of other manufacturers (see Fig. 8/12).

Because of the standardized interfaces, SIPROTEC units can also be integrated into systems of other manufacturers or in SIMATIC. Electrical RS485 or optical interfaces are available. The optimum physical data transfer medium can be chosen thanks to opto-electrical converters. Thus, the RS485 bus allows low-cost wiring in the cubicles and an interference-free optical connection to the master can be established.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbits/s Ethernet bus, the units are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 8/14).

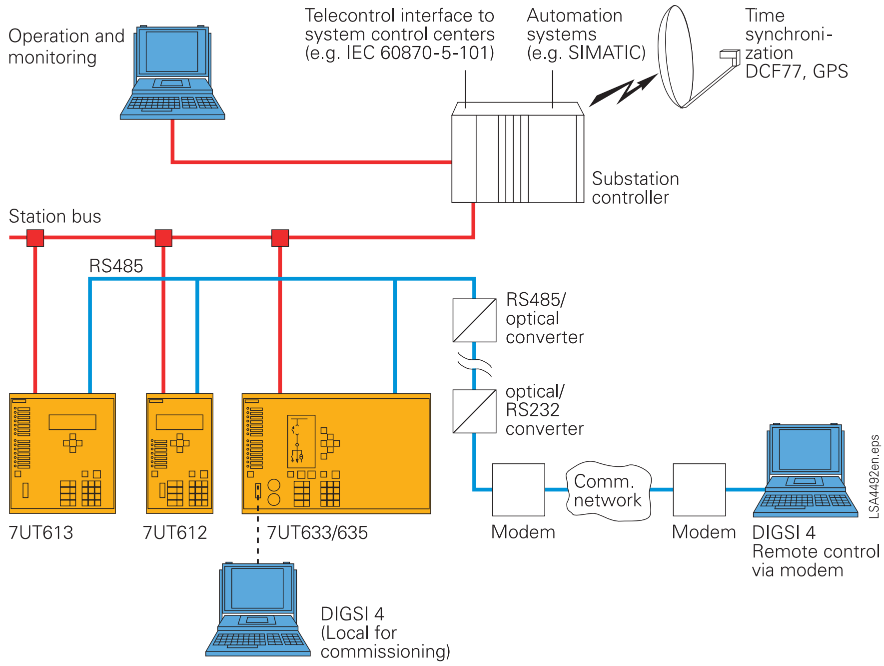


Fig. 8/19
System solution: Communications

Typical connections

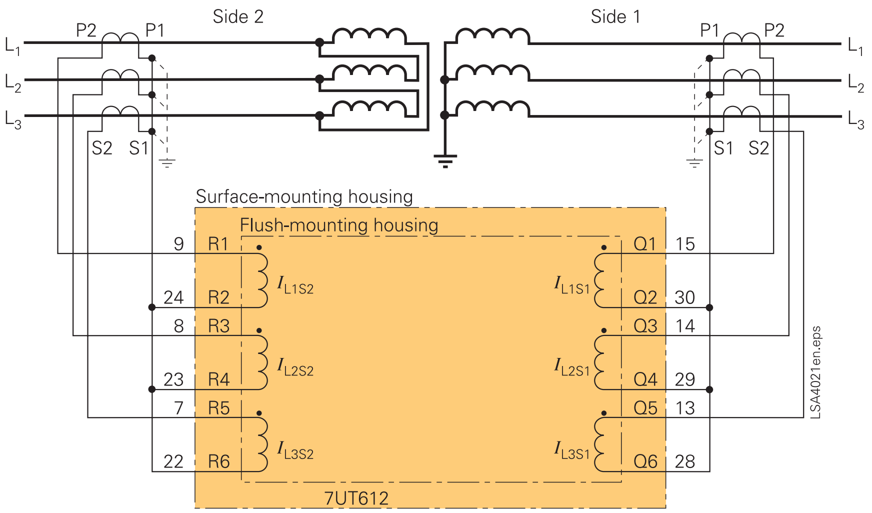


Fig. 8/20
Standard connection to a transformer without neutral current measurement

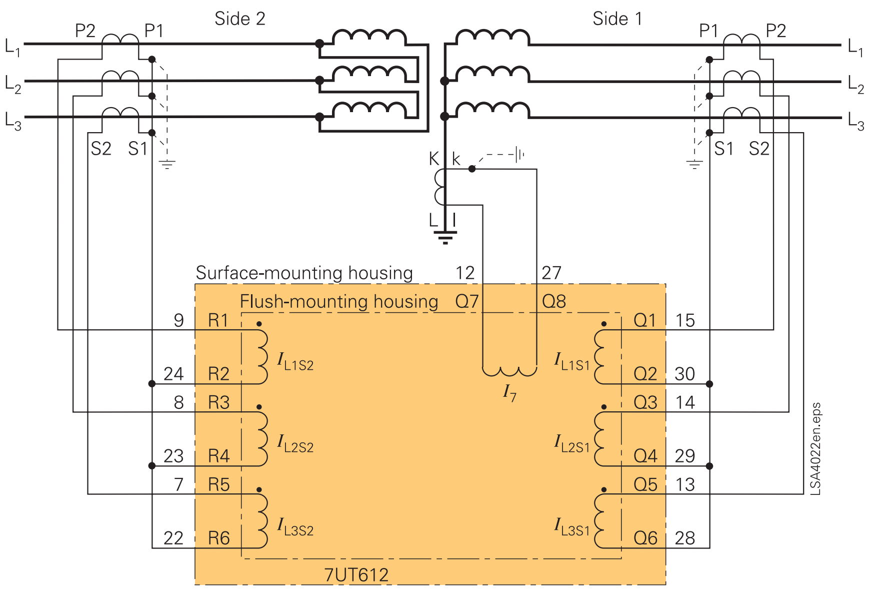


Fig. 8/21
Connection to a transformer with neutral current measurement

Typical connections

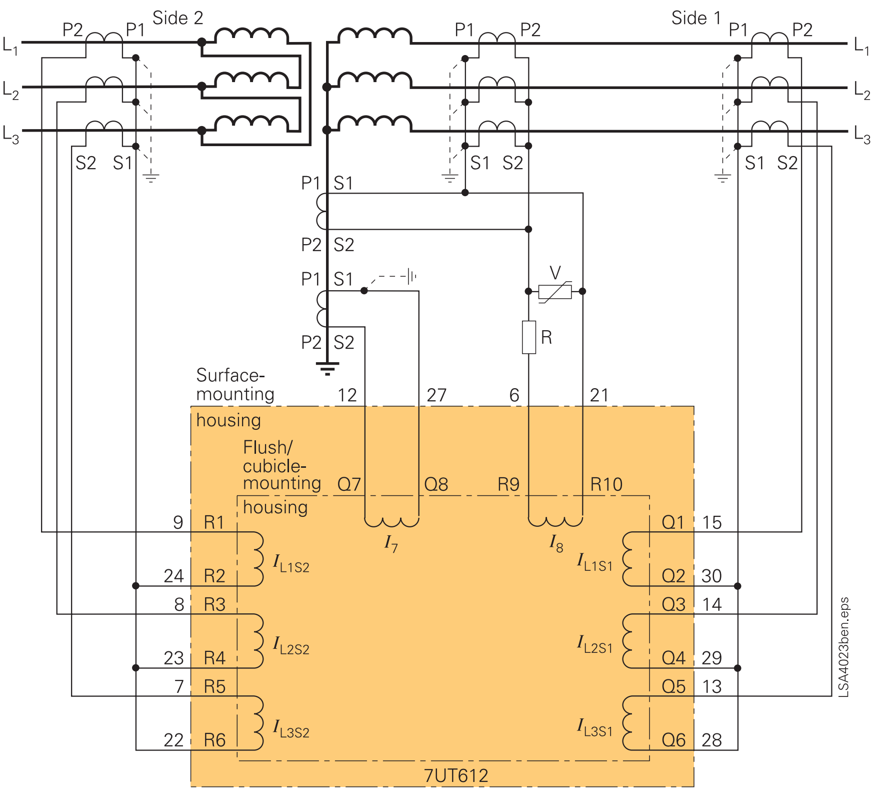


Fig. 8/22
Connection of transformer differential protection with high impedance REF (I_7) and neutral current measurement at I_8

Typical connections

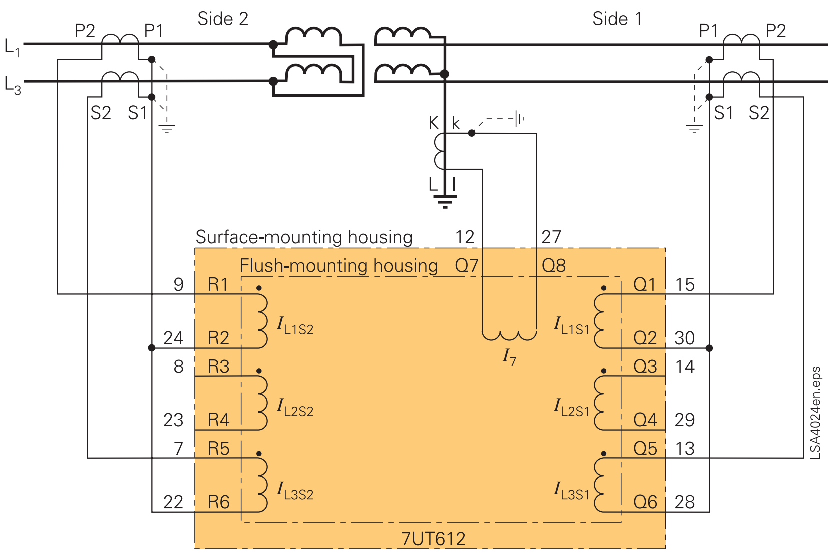


Fig. 8/23
Connection example to a single-phase power transformer with current transformer between starpoint and earthing point

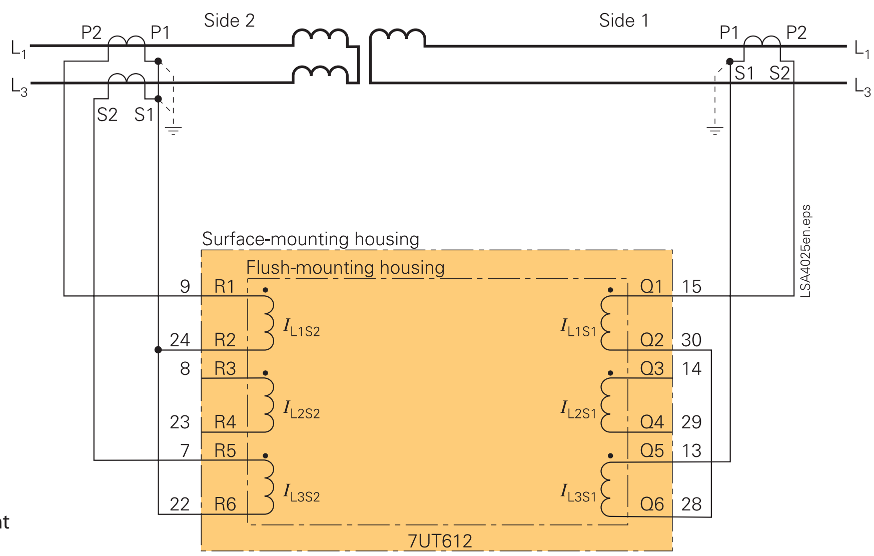


Fig. 8/24
Connection example to a single-phase power transformer with only one current transformer (right side)

8

Typical connections

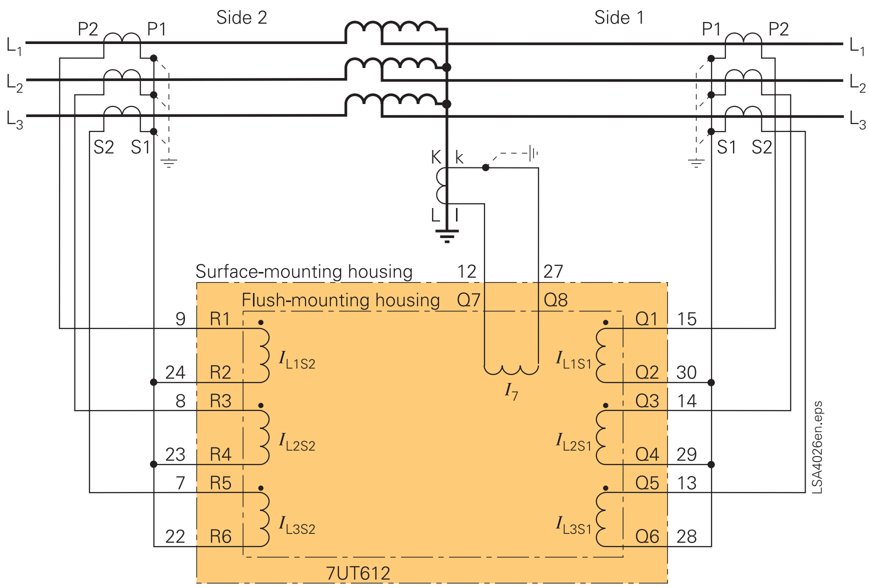


Fig. 8/25
Connection to a three-phase auto-transformer with current transformer between starpoint and earthing point

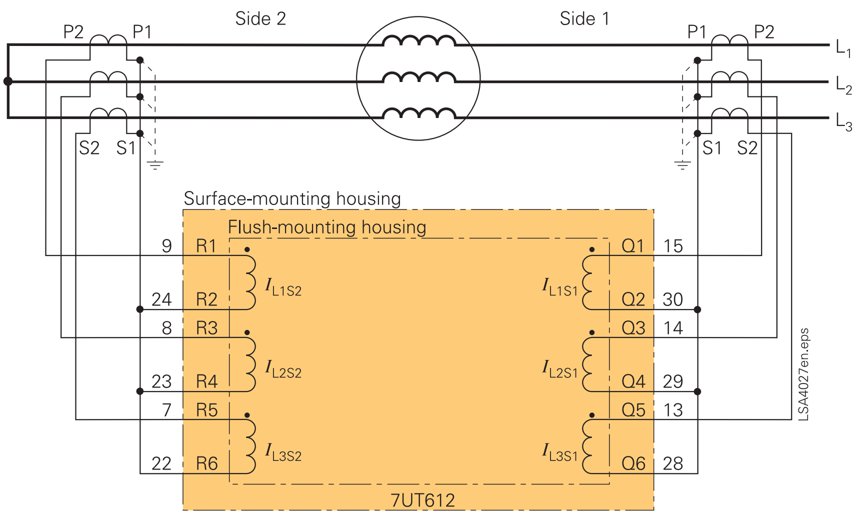


Fig. 8/26
Generator or motor protection

8

Typical connections

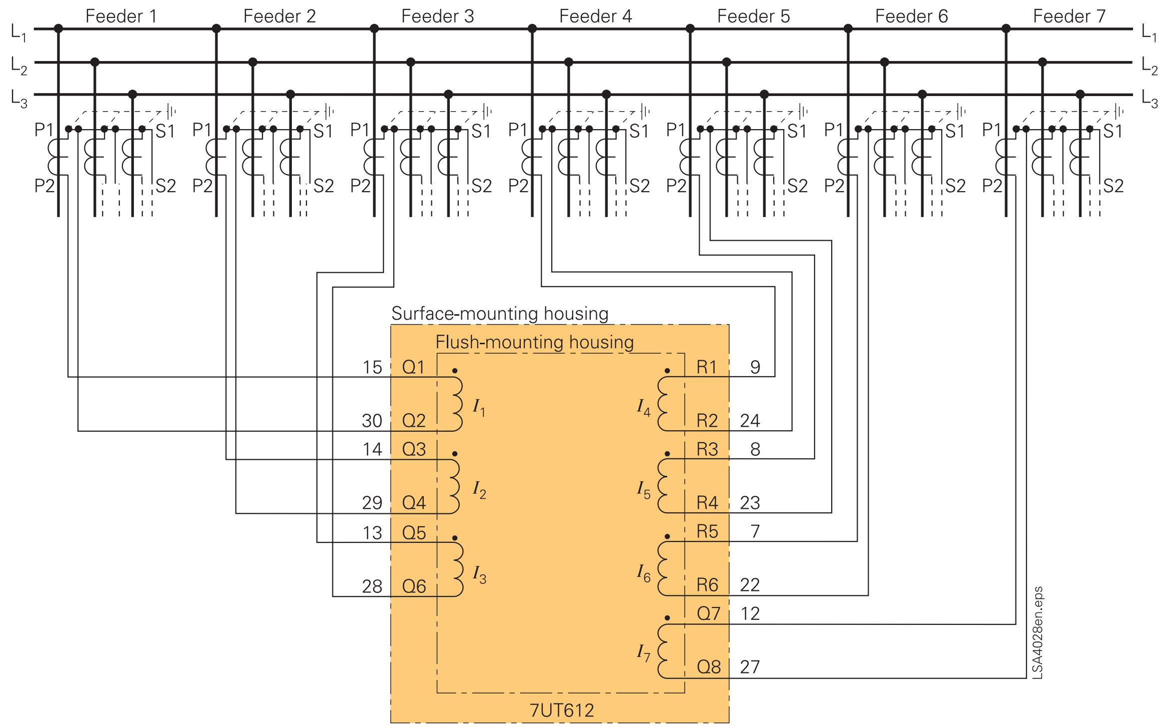


Fig. 8/27
Connection 7UT612 as single-phase busbar protection for 7 feeders, illustrated for phase L1

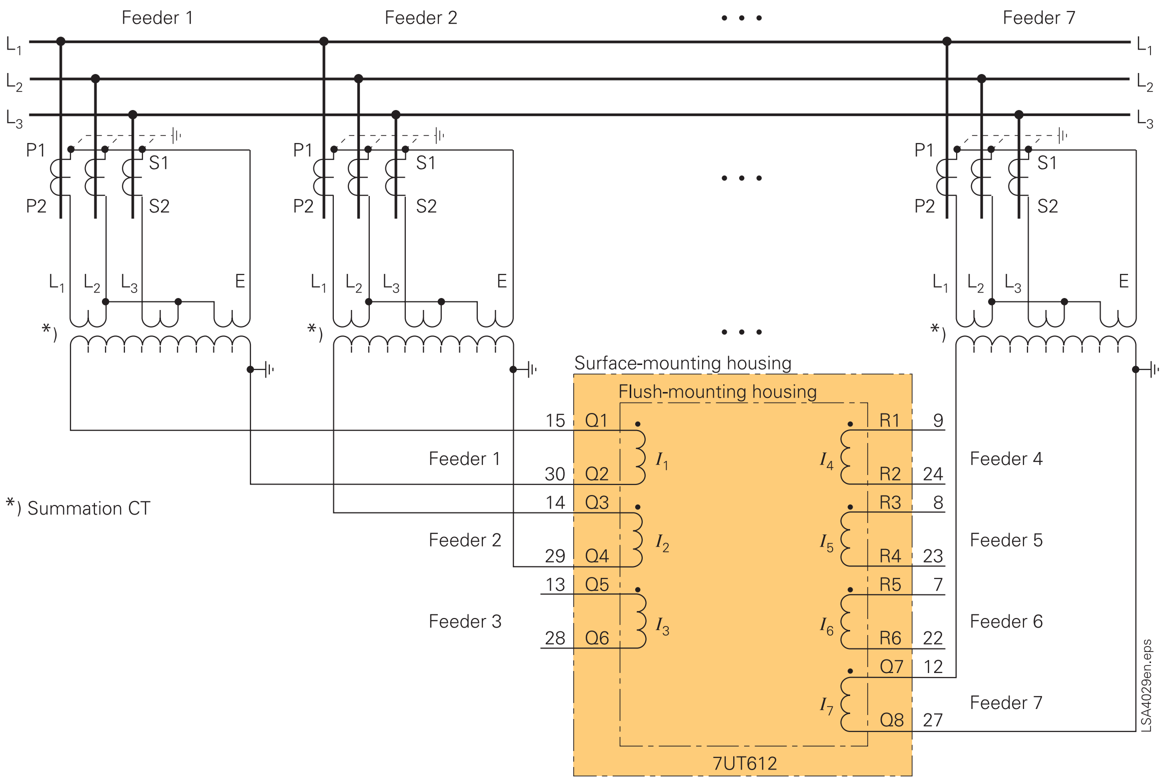


Fig. 8/28
Connection 7UT612 as busbar protection for feeders, connected via external summation current transformers (SCT) – partial illustration for feeders 1, 2 and 7

Typical connections

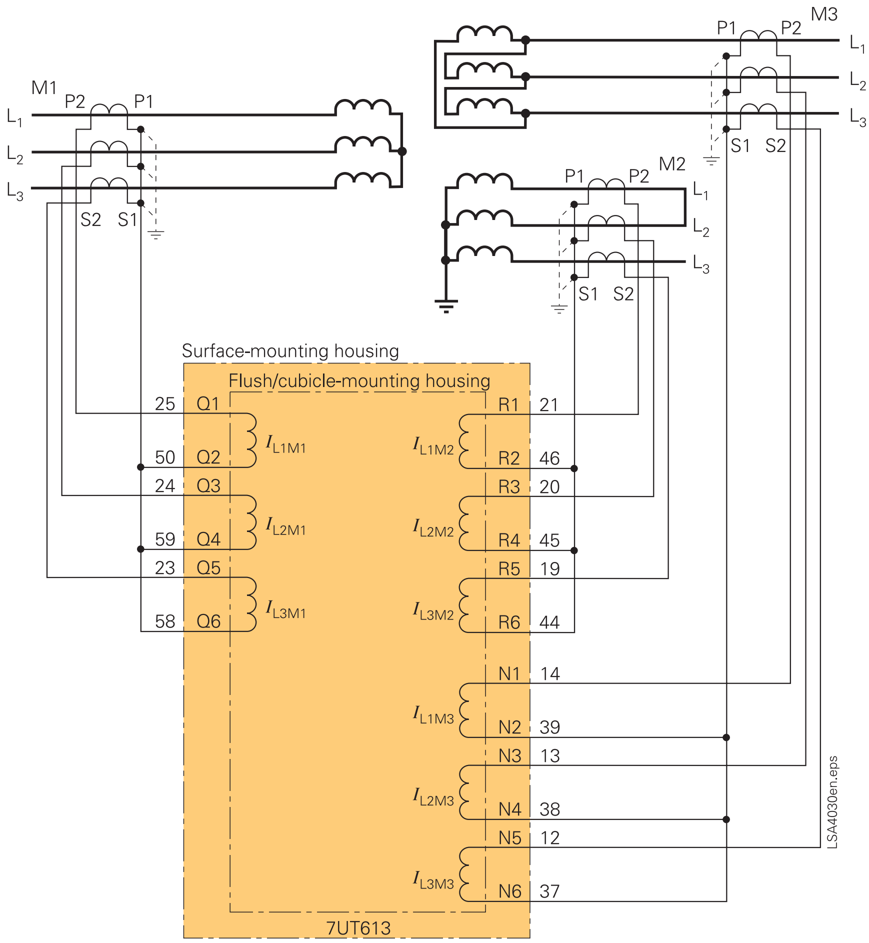


Fig. 8/29
Connection example 7UT613 for a three-winding power transformer

Typical connections

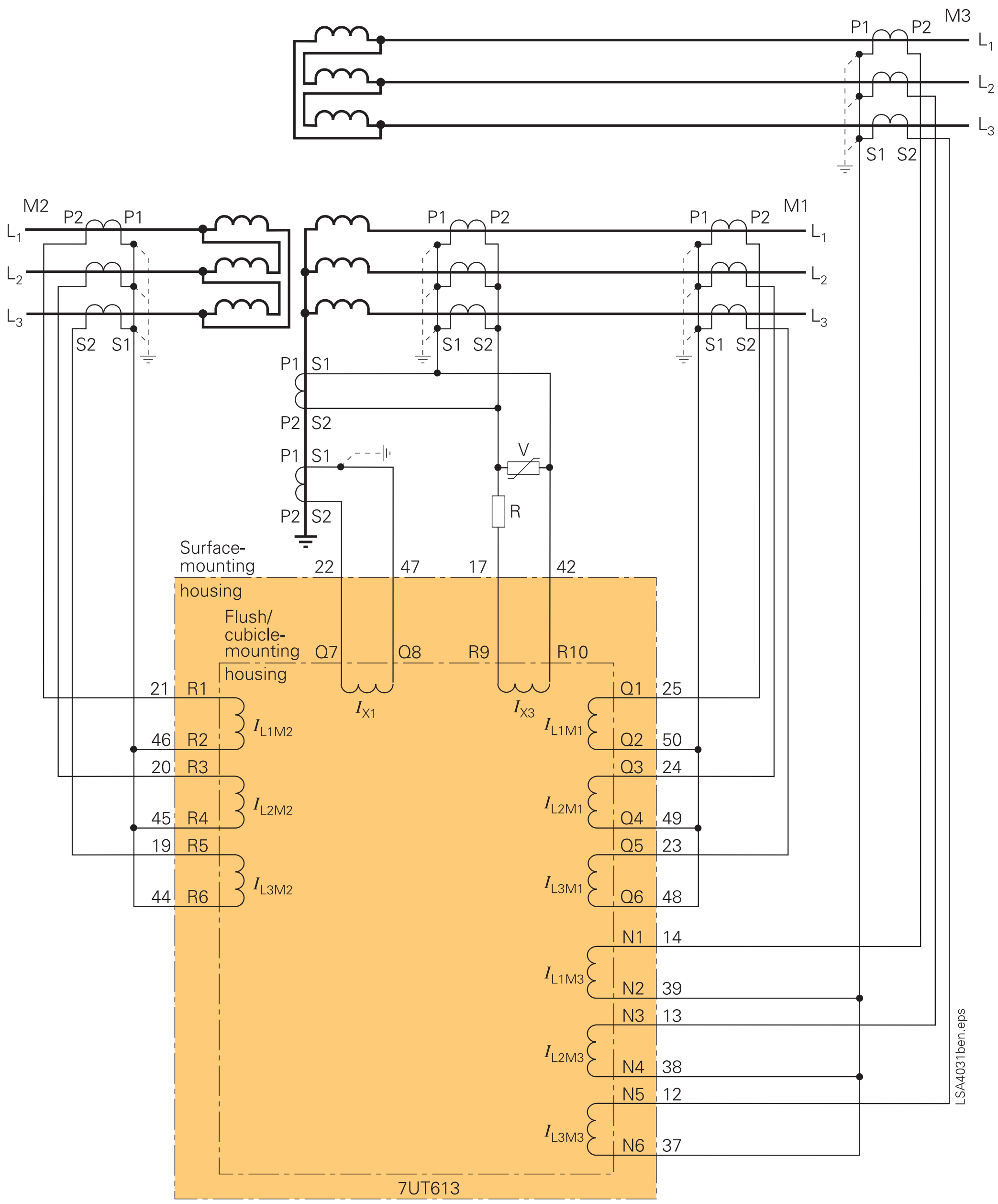


Fig. 8/30
Connection example 7UT613 for a three-winding power transformer with current transformers between starpoint and earthing point, additional connection for high-impedance protection; I_{X3} connected as high-sensitivity input

8

Typical connections

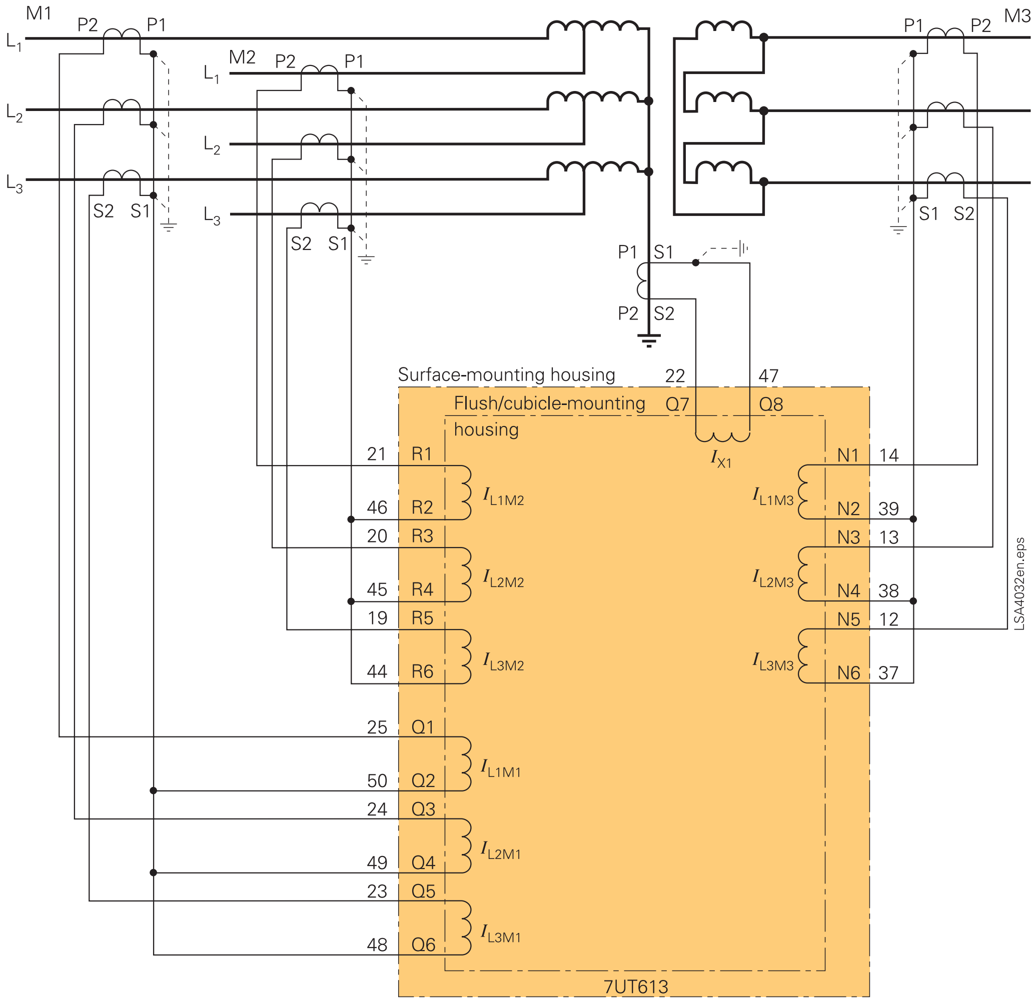
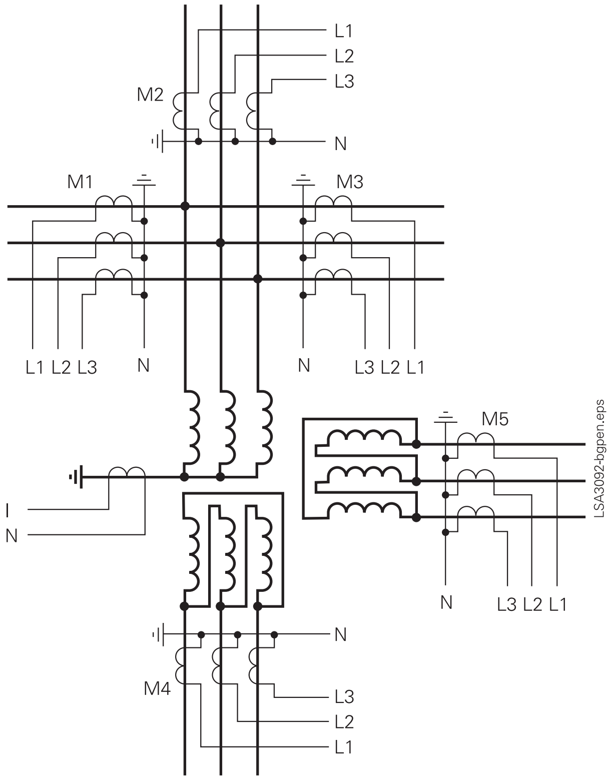


Fig. 8/31
Connection example 7UT613 for a three-phase auto-transformer with three-winding and current transformer between starpoint and earthing point

Typical connections



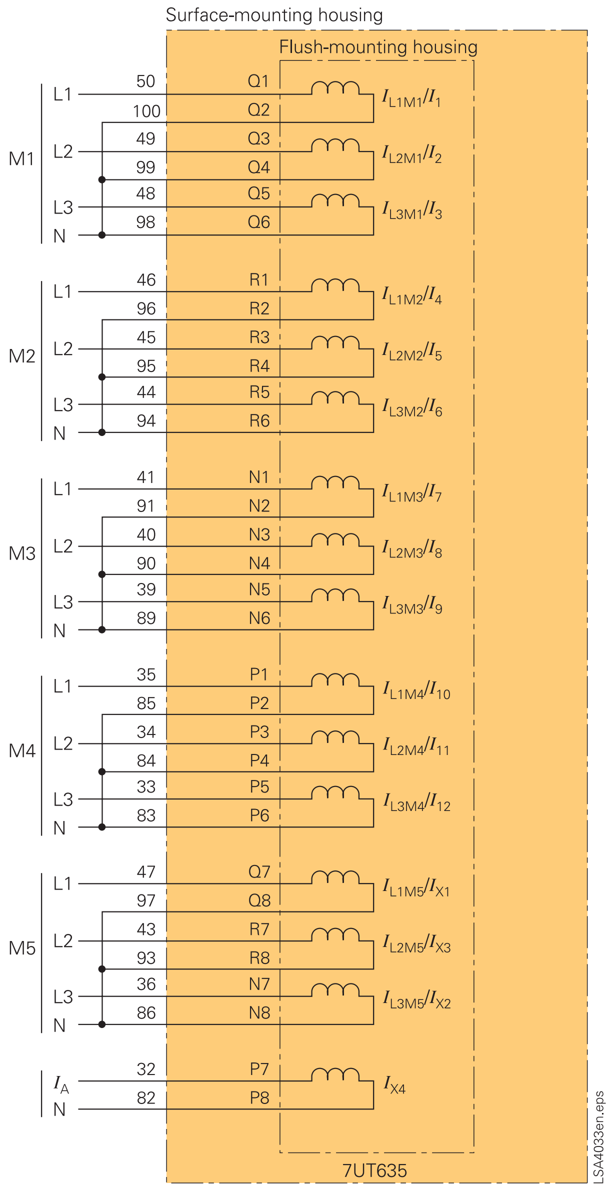


Fig. 8/32
Connection example 7UT635 for a three-winding power transformer with 5 measurement locations (3-phase) and neutral current measurement

Typical connections

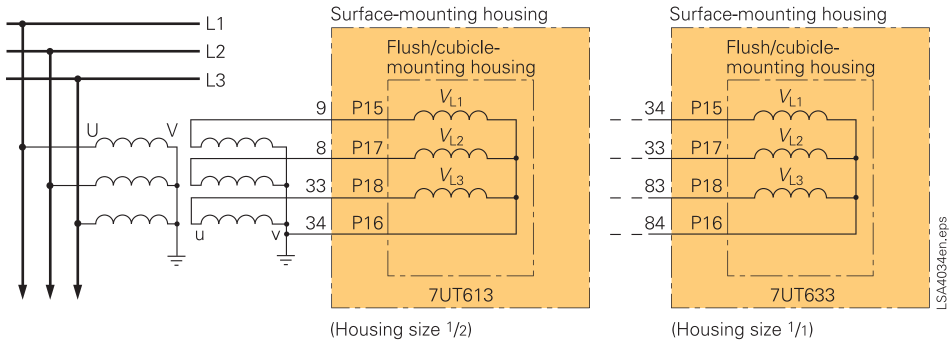


Fig. 8/33
Voltage transformer connection to 3 star-connected voltage transformers (7UT613 and 7UT633 only)

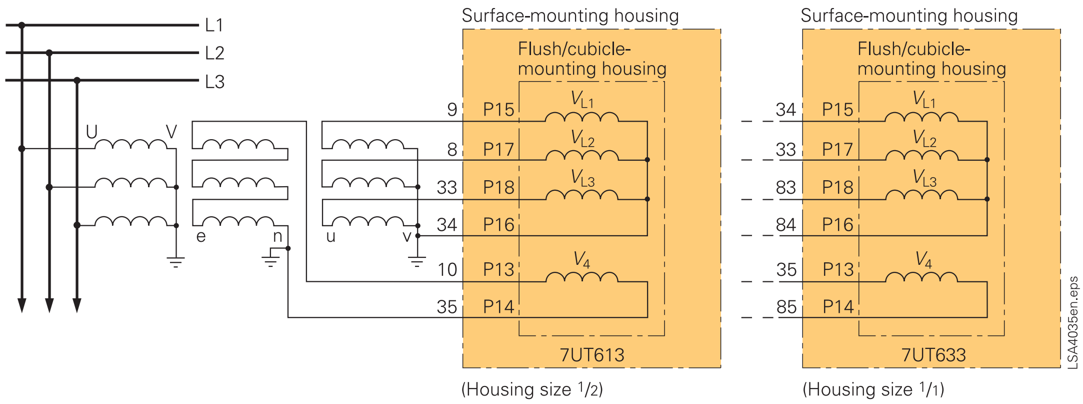


Fig. 8/34
Voltage transformer connection to 3 star-connected voltage transformers with additional delta winding (e-n-winding) (7UT613 and 7UT633 only)

Technical data

General unit data

Analog inputs

Rated frequency	50 or 60 Hz (selectable)			
Rated current	0.1 or 1 or 5 A (selectable by jumper, 0.1 A)			
Power consumption	7UT			
In CT circuits	612	613	633	635
with I_N = 1 A; in VA approx.	0.02	0.05	0.05	0.05
with I_N = 5 A; in VA approx.	0.2	0.3	0.3	0.3
with I_N = 0.1 A; in VA approx.	0.001	0.001	0.001	0.001
sensitive input; in VA approx.	0.05	0.05	0.05	0.05
Overload capacity In CT circuits	I_N			
Thermal (r.m.s.)	100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous			
Dynamic (peak value)	250 I_N (half cycle)			
In CT circuits for highly sensitive input I_{EE} Thermal	300 A for 1 s 100 A for 10 s 15 A continuous			
Dynamic	750 A (half cycle)			
Rated voltage (7UT613/633 only) Power consumption per phase at 100 V	80 to 125 V ≤ 0.1 VA			
Overload capacity Thermal (r.m.s.)	230 V continuous			

Auxiliary voltage

Rated voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V AC (50/60 Hz), 230 V AC			
Permissible tolerance	-20 to +20 %			
Superimposed AC voltage (peak-to-peak)	≤ 15 %			
Power consumption (DC/AC)	7UT			
	612	613	633	635
Quiescent; in W approx.	5	6/12	6/12	6/12
Energized; in W approx. depending on design	7	12/19	20/28	20/28
Bridging time during failure of the auxiliary voltage V_{aux} ≥ 110 V	≥ 50 ms			

Binary inputs

Functions are freely assignable				
Quantity marshallable	7UT			
	612	613	633	635
	3	5	21	29
Rated voltage range	24 to 250 V, bipolar			
Minimum pickup threshold Ranges are settable by means of jumpers for each binary input	19 or 88 V DC (bipolar)			
Maximum permissible voltage	300 V DC			
Current consumption, energized	Approx. 1.8 mA			

Output relay

Command / indication / alarm relay				
Quantity	7UT			
each with 1 NO contact	612	613	633	635
(marshallable) 1 alarm contact, with 1 NO or NC contact (not marshallable)	4	8	24	24
Switching capacity				
Make	1000 W / VA			
Break	30 VA			
Break (with resistive load)	40 W			
Break (with L/R ≤ 50 ms)	25 W			
Switching voltage	250 V			
Permissible total current	30 A for 0.5 seconds 5 A continuous			
Operating time, approx.				
NO contact	8 ms			
NO/NC contact (selectable)	8 ms			
Fast NO contact	5 ms			
High-speed*) NO trip outputs	< 1 ms			

LEDs

Quantity	7UT			
	612	613	633	635
RUN (green)	1	1	1	1
ERROR (red)	1	1	1	1
LED (red), function can be assigned	7	14	14	14

Unit design

Housing 7XP20	For dimensions please refer to dimension drawings			
Degree of protection acc. to IEC 60529				
For the device				
in surface-mounting housing	IP 51			
in flush-mounting housing				
front	IP 51			
rear	IP 50			
For personal safety	IP 2x with closed protection cover			
Housing	7UT			
	612	613	633	635
Size, referred to 19" frame	1/3	1/2	1/1	1/1
Weight, in kg				
Flush-mounting housing	5.1	8.7	13.8	14.5
Surface-mounting housing	9.6	13.5	22.0	22.7

Serial interfaces

Operating interface 1 for DIGSI 4 or browser

Connection	Front side, non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Transmission rate in kbaud Setting as supplied: 38.4 kbaud, parity 8E1	7UT612: 4.8 to 38.4 kbaud 7UT613/633/635: 4.8 to 115 kbaud
Distance, max.	15 m

Time synchronization DCF77 / IRIG-B signal / IRIG-B000

Connection	Rear side, 9-pin subminiature connector (SUB-D) (terminals with surface-mounting housing)
Voltage levels	5, 12 or 24 V (optional)

Service interface (operating interface 2) for DIGSI 4 / modem / service

Isolated RS232/RS485/FO	9-pin subminiature connector (SUB-D)
Dielectric test	500 V / 50 Hz
Distance for RS232	Max. 15 m / 49.2 ft
Distance for RS485	Max. 1000 m / 3300 ft
Distance for FO	1.5 km (1 mile)

*) With high-speed contacts all operating times are reduced by 4.5 ms.

Technical data

System interface	
IEC 61850	
Ethernet, electrical (EN 100) for IEC 61850 and DIGSI	
Connection	
for flush-mounting case	Rear panel, mounting location "B", two RJ45 connector, 100 Mbit acc. to IEEE802.3
for surface-mounting case	At bottom part of the housing
Test voltage	500 V; 50 Hz
Transmission Speed	100 Mbits/s
Distance	20 m/66 ft
Ethernet, optical (EN 100) for IEC 61850 and DIGSI	
Connection	
for flush-mounting case	Rear panel, mounting location "B", ST connector receiver/transmitter
for surface-mounting case	Not available
Optical wavelength	λ = 1350 nm
Transmission Speed	100 Mbits/s
Laser class 1 acc. to EN 60825-1/-2	glass fiber 50/125 µm or glass fiber 62/125µm
Permissible path attenuation	Max. 5 dB for glass fiber 62.5/125µm
Distance	Max. 800 m/0.5 mile
IEC 60870-5-103	
Isolated RS232/RS485/FO	9-pin subminiature connector (SUB-D)
Baud rate	4800 to 19200 baud
Dielectric test	500 V/50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
For fiber-optic cable	
Connector type	ST connector
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 µm
Distance	Max. 1.5 km
PROFIBUS RS485 (-FMS/-DP)	
Connector type	9-pin subminiature connector (SUB-D)
Baud rate	Max. 1.5 Mbaud
Dielectric test	500 V / 50 Hz
Distance	Max. 1000 m (3300 ft) at ≤ 93.75 kbaud
PROFIBUS fiber optic (-FMS/-DP)	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[1]
Baud rate	Max. 1.5 Mbaud
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 µm
Distance	500 kbaud 1.6 km (0.99 miles) 1500 kbaud 530 m (0.33 miles)
DNP 3.0 RS485 / MODBUS RS485	
Connector type	9-pin subminiatur connector (SUB-D)
Baud rate	Max. 19200 baud
Dielectric test	500 V / 50 Hz
Distance	Max. 1000 m (3300 ft)
DNP 3.0 Optical/MODBUS FO	
Connector type	ST connector
Optical wavelength	λ = 820 nm
Permissible attenuation	Max. 8 dB, for glass-fiber 62.5/125 µm
Distance	1.5 km (1 mile)

1) Conversion with external OLM
For fiber-optic interface please complete Order No. at 11th position with 4 (FMS RS485) or 9 (DP RS485) and Order code L0A and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Electrical tests	
Specifications	
Standards	IEC 60255 (Product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508
Insulation tests	
Standards	IEC 60255-5 and 60870-2-1
Voltage test (100 % test)	
All circuits except for auxiliary supply, binary inputs and communication interfaces	2.5 kV (r.m.s.), 50 Hz / 60 Hz
Auxiliary voltage and binary inputs (100 % test)	3.5 kV DC
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 Hz / 60 Hz
Impulse voltage test (type test)	
All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for interference immunity	
Standards	IEC 60255-6, 60255-22 (product standards) EN 6100-6-2 (generic standard) DIN 57435 / Part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 / Part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 ms; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, frequency sweep, IEC 60255-22-3, IEC 61000-4-3 class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHZ
Irradiation with RF field, amplitude-modulated, single frequencies, IEC 60255-22-3, IEC 61000-4-3, class III	10 V/m; 80, 160, 450, 900 MHz, 80 % AM; duration > 10 s
Irradiation with RF field, pulse-modulated, single frequencies, IEC 60255-22-3, IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 % PM
Fast transients interference, bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5, installation class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2kV; 12 Ω, 9 µF Differential (transversal) mode: 1kV; 2 Ω, 18 µF
Analog inputs, binary inputs, binary outputs	Common (longitude) mode: 2kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz

Technical data

Electrical tests *(cont'd)*	
***EMC tests for interference immunity** (cont'd)*	
Magnetic field with power frequency IEC 61000-4-8, IEC 60255-6 class IV	30 A/m continuous; 300 A/m for 3 s; 50 Hz, 0.5 mT; 50 Hz
Oscillatory surge withstand capability, ANSI/IEEE C37.90.1	2.5 kV (peak); 1 MHz; τ = 15 µs; Damped wave; 400 surges per second; duration 2 s; R_i = 200 Ω
Fast transient surge withstand capability, ANSI/IEEE C37.90.1	4 kV; 5/50 ns; 5 kHz; burst 15 ms; repetition rate 300 ms; both polarities; duration 1 min.; R_i = 80 Ω
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz, R_i = 200 Ω
***EMC tests for interference emission** (type test)*	
Standard	EN 50081-* (generic standard)
Conducted interference, only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strenght IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
<u>During operation</u>	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration frequency sweep 1 octave/min. 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
<u>During transport</u>	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60255-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to +131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Yearly average ≤ 75 % relative humidity; on 56 days in the year up to 93 % relative humidity; condensation not permitted

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits ("Low voltage" Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/ Part 303).

Further applicable standards: ANSI/IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

8

Technical data

Functions		
Differential protection		
General		
Pickup values		
Differential current $I_{DIFF} > / I_{Nobj}$	0.05 to 2.00	(steps 0.01)
High-current stage $I_{DIFF} >> / I_{Nobj}$	0.5 to 35.0 or deactivated	(steps 0.1) (stage ineffective)
Pickup on switch-on (factor of I_{DIFF} >)	1.0 to 2.0	(steps 0.1)
Add-on stabilization on external fault (I_{STAB} > set value) I_{add-on} / I_{Nobj} action time	2.00 to 15.00 2 to 250 cycles or deactivated	(steps 0.01) (steps 1 cycle) (effective until dropoff)
Tolerances (at preset parameters) I_{DIFF} > stage and characteristic I_{DIFF} >> stage	 5 % of set value 5 % of set value	
Time delays		
Delay of I_{DIFF} > stage $T_{I\text{-}DIFF>}$	0.00 to 60.00 s or deactivated	(steps 0.01 s) (no trip)
Delay of I_{DIFF} >> stage $T_{I\text{-}DIFF>>}$	0.00 to 60.00 s or deactivated	(steps 0.01 s) (no trip)
Time tolerance	1 % of set value or 10 ms	
The set times are pure delay times		
Transformers		
Harmonic stabilization		
Inrush restraint ratio (2nd harmonic) I_{2fN}/I_{fN}	10 to 80 %	(steps 1 %)
Stabilization ratio further (n-th) harmonic (optional 3rd or 5th) I_{nfN}/I_{fN}	10 to 80 %	(steps 1 %)
Crossblock function max. action time for crossblock	Can be activated / deactivated 2 to 1000 AC cycles (steps 1 cycle) or 0 (crossblock deactivated) or deactivated (active until dropout)	
Operating times		
Pickup time/dropout time with single-side infeed		
Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612 I_{DIFF} >, min. I_{DIFF} >>, min.	 38 19	 35 17
Dropout time (in ms), approx.	35	30
7UT 613/63x I_{DIFF} >, min. I_{DIFF} >>, min.	 30 11	 27 11
Dropout time (in ms), approx.	54	46
Dropout ratio, approx.	0.7	
Current matching for transformers		
Vector group adaptation	0 to 11 (x 30 °) (steps 1)	
Star-point conditioning	Earthed or non-earthed (for each winding)	

Generators, motors, reactors		
Operating times		
Pickup time/dropout time with single-side infeed		
Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612 I_{DIFF} >, min. I_{DIFF} >>, min.	 38 19	 35 17
Dropout time (in ms), approx.	35	30
7UT 613/63x I_{DIFF} >, min. I_{DIFF} >>, min.	 30 11	 27 11
Dropout time (in ms), approx.	54	46
Dropout ratio, approx.	0.7	
Busbars, short lines		
Differential current monitor		
Steady-state differential current monitoring $I_{DIFF\ mon}/I_{Nobj}$	0.15 to 0.80	(steps 0.01)
Delay of blocking with differential current monitoring $T_{DIFF\ mon}$	1 to 10 s	(steps 1 s)
Feeder current guard		
Trip release I_{guard}/I_{Nobj} by feeder current guard	0.20 to 2.00 or 0 (always released)	(steps 0.01)
Operating times		
Pickup time/dropout time with single-side infeed		
Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612 I_{DIFF} >, min. I_{DIFF} >>, min.	 25 19	 25 17
Dropout time (in ms), approx.	30	30
7UT 613/63x I_{DIFF} >, min. I_{DIFF} >>, min.	 11 11	 11 11
Dropout time (in ms), approx.	54	46
Dropout ratio, approx.	0.7	

Technical data

Restricted earth-fault protection

Multiple availability		2 times (option)
Settings		
Differential current $I_{REF} > / I_{Nobj}$		0.05 to 2.00 (steps 0.01)
Limit angle	φ_{REF}	110 ° (fixed)
Time delay	T_{REF}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
The set times are pure delay times		

Operating times

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612	40	38
At 1.5 · setting value $I_{REF} >$, approx.	37	32
At 2.5 · setting value $I_{REF} >$, approx.	40	40
Dropout time (in ms), approx.		
7UT 613/63x	35	30
At 1.5 · setting value $I_{REF} >$, approx.	33	29
At 2.5 · setting value $I_{REF} >$, approx.	26	23
Dropout time (in ms), approx.	0.7	
Dropout ratio, approx.		

Overcurrent-time protection for phase and residual currents

Multiple availability		3 times (option)
Characteristics		
Definite-time stages (DT)		I_{Ph} >>, $3I_0$ >>, I_{Ph} >, $3I_0$ >
Inverse-time stages (IT)		I_P, $3I_{0P}$
Acc. to IEC		Inverse, very inverse, extremely inverse, long-time inverse
Acc. to ANSI		Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse
		Alternatively, user-specified trip and reset characteristics
Reset characteristics (IT)		Acc. to ANSI with disk emulation
Current stages		
High-current stages	I_{Ph} >>	0.10 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	T_{IPh} >>	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_0$ >>	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	T_{3I0} >>	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stages	I_{Ph} >	0.10 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	T_{IPh}	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_0$ >	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	T_{3I0} >	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_P	0.10 to 4.00 A [1] (steps 0.01 A)
Acc. to IEC	T_{IP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
	$3I_{0P}$	0.05 to 4.00 A [1] (steps 0.01 A)
	T_{3I0P}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_P	0.10 to 4.00 A [1] (steps 0.01 A)
Acc. to ANSI	D_{IP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
	$3I_{0P}$	0.05 to 4.00 A [1] (steps 0.01 A)
	D_{3I0P}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)

Current stages (cont'd)

Tolerances		
Definite time	Currents Times	3 % of set value or 1 % of rated current 1 % of set value or 10 ms
Inverse time	Currents	Pickup at $1.05 \leq I/I_P \leq 1.15$; or $1.05 \leq I/3I_{0P} \leq 1.15$
Acc. to IEC	Times	5 % ± 15 ms at f_N = 50/60 Hz for $2 \leq I/I_P \leq 20$ and $T_{IP}/s \geq 1$; or $2 \leq I/3I_{0P} \leq 20$ and $T_{3I0P}/s \geq 1$
Acc. to ANSI	Times	5 % ± 15 ms at f_N = 50/60 Hz for $2 \leq I/I_P \leq 20$ and $D_{IP}/s \geq 1$; or $2 \leq I/3I_{0P} \leq 20$ and $D_{3I0P}/s \geq 1$

The set definite times are pure delay times.

Operating times of the definite-time stages

Pickup time/dropout time phase current stages

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT612		
Without inrush restraint, min.	20	18
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
7UT613/6x		
Without inrush restraint, min.	11	11
With inrush restraint, min.	33	29
Dropout time (in ms), approx.	35	35

Pickup time/dropout time residual current stages

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612		
Without inrush restraint, min.	40	35
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
7UT613/6x		
Without inrush restraint, min.	21	19
With inrush restraint, min.	31	29
Dropout time (in ms), approx.	45	43

Dropout ratios

Current stages	Approx. 0.95 for $I/I_N \geq 0.5$

Inrush blocking

Inrush blocking ratio (2nd harmonic) I_{2fN}/I_{fN}	10 to 45 % (steps 1 %)
Lower operation limit	I > 0.2 A [1]
Max. current for blocking	0.30 to 25.00 A [1] (steps 0.01 A)
Crossblock function between phases max. action time for crossblock	Can be activated/deactivated 0.00 to 180 s (steps 0.01 A)

1) Secondary values based on I_N = 1 A;
for I_N = 5 A they must be multiplied by 5.

8

Technical data

Overcurrent-time protection for earth current

Multiple availability		3 times (option)
Characteristics		
Definite-time stages (DT)		$I_E >>$, $I_E >$
Inverse-time stages (IT)		I_{EP}
Acc. to IEC		Inverse, very inverse, extremely inverse, long-time inverse
Acc. to ANSI		Inverse, moderately inverse, very inverse, extremely inverse, definite inverse, short inverse, long inverse
		Alternatively, user-specified trip and reset characteristics
Reset characteristics (IT)		Acc. to ANSI with disk emulation
Current stages		
High-current stage	$I_E >>$	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IE} >>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stage	$I_E >$	0.05 to 35.00 A [1] (steps 0.01 A) or deactivated (stage ineffective)
	$T_{IE} >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_{EP}	0.05 to 4.00 A [1] (steps 0.01 A)
Acc. to IEC	T_{IEP}	0.05 to 3.20 s (steps 0.01 s) or deactivated (no trip)
Inverse-time stages	I_{EP}	0.05 to 4.00 A [1] (steps 0.01 A)
Acc. to ANSI	D_{IEP}	0.50 to 15.00 s (steps 0.01 s) or deactivated (no trip)
Tolerances		
Definite time	Currents	3 % of set value or 1 % of rated current
	Times	1 % of set value or 10 ms
Inverse time	Currents	Pickup at $1.05 \leq I/I_{EP} \leq 1.15$
Acc. to IEC	Times	5 % ± 15 ms at f_N = 50/60 Hz for $2 \leq I/I_{EP} \leq 20$ and $T_{IEP}/s \geq 1$
Acc. to ANSI	Times	5 % ± 15 ms at f_N = 50/60 Hz for $2 \leq I/I_{EP} \leq 20$ and $D_{IEP}/s \geq 1$

The set definite times are pure delay times.

Operating times of the definite-time stages

Pickup time/dropout time

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT 612		
Without inrush restraint, min.	20	18
With inrush restraint, min.	40	35
Dropout time (in ms), approx.	30	30
7UT613/63x		
Without inrush restraint, min.	11	11
With inrush restraint, min.	33	29
Dropout time (in ms), approx.	35	35

Dropout ratios

Current stages	Approx. 0.95 for $I/I_N \geq 0.5$

Inrush blocking

Inrush blocking ratio (2nd harmonic) I_{2fN}/I_{fN}	10 to 45 %	(steps 1 %)
Lower operation limit	$I > 0.2$ A [1]	
Max. current for blocking	0.30 to 25.00 A [1]	(steps 0.01 A)

1) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied by 5.

Dynamic cold-load pickup for overcurrent-time protection

Time control

Start criterion		Binary input from circuit-breaker auxiliary contact or current criterion (of the assigned side)
CB open time	$T_{CB\ open}$	0 to 21600 s (= 6 h) (steps 1 s)
Active time	$T_{Active\ time}$	1 to 21600 s (= 6 h) (steps 1 s)
Accelerated dropout time	$T_{Stop\ time}$	1 to 600 s (= 10 min) (steps 1 s) or deactivated (no accelerated dropout)

Setting ranges and changeover values

Dynamic parameters of current pickup and delay times or time multipliers	Setting ranges and steps are the same as for the functions to be influenced

Single-phase overcurrent-time protection

Current stages

High-current stage $I >>$		0.05 to 35.00 A [1] (steps 0.01 A) 0.003 to 1.500 A [2] (steps 0.001 A) or deactivated (stage ineffective)
	$T_I >>$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Definite-time stage $I >$		0.05 to 35.00 A [1] (steps 0.01 A) 0.003 to 1.500 A [2] (steps 0.001 A) or deactivated (stage ineffective)
	$T_I >$	0.00 to 60.00 s (steps 0.01 s) or deactivated (no trip)
Tolerances	Currents	3 % of set value or 1 % of rated current at I_N = 1 A or 5 A; 5 % of set value or 3 % of rated current at I_N = 0.1 A
	Times	1 % of set value or 10 ms

The set definite times are pure delay times.

Operating times

Pickup time/dropout time

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT612	20	18
Minimum	30	27
Dropout time (in ms), approx.		
7UT613/63x	14	13
Minimum	25	22
Dropout time (in ms), approx.		

Dropout ratios

Current stages	Approx. 0.95 for $I/I_N \geq 0.5$

2) Secondary values for high-sensitivity current input I_8, independent of rated current.

Technical data

Unbalanced load protection (Negative-sequence protection)

Characteristics

Definite-time stages	(DT)	$I_2 >>$, $I_2 >$
Inverse-time stages	(IT)	I_{2P}
Acc. to IEC		Inverse, very inverse, extremely inverse
Acc. to ANSI		Inverse, moderately inverse, very inverse, extremely inverse
Reset characteristics	(IT)	Acc. to ANSI with disk emulation
Operating range		0.1 to 4 A [1]

Current stages

High-current stage	$I_2 >>$	0.10 to 3.00 A [1]	(steps 0.01 A)
	$T_{I2} >>$	0.00 to 60.00 s	(steps 0.01 s)
		or deactivated (no trip)	
Definite-time stage	$I_2 >$	0.10 to 3.00 A [1]	(steps 0.01 A)
	$T_{I2} >$	0.00 to 60.00 s	(steps 0.01 s)
		or deactivated (no trip)	
Inverse-time stages	I_{2P}	0.10 to 2.00 A [1]	(steps 0.01 A)
Acc. to IEC	T_{I2P}	0.05 to 3.20 s	(steps 0.01 s)
		or deactivated (no trip)	
Inverse-time stages	I_{2P}	0.10 to 2.00 A [1]	(steps 0.01 A)
Acc. to ANSI	D_{I2P}	0.50 to 15.00 s	(steps 0.01 s)
		or deactivated (no trip)	

Tolerances		
Definite-time	Currents	3 % of set value or 1 % of rated current
	Times	1 % of set value or 10 ms
Inverse time	Currents	Pickup at $1.05 \leq I/I_{EP} \leq 1.15$
Acc. to IEC	Times	5 % ± 15 ms at $f_N = 50/60$ Hz for $2 \leq I/I_{EP} \leq 20$ and $T_{IEP}/s \geq 1$
Acc. to ANSI	Times	5 % ± 15 ms at $f_N = 50/60$ Hz for $2 \leq I/I_{EP} \leq 20$ and $D_{IEP}/s \geq 1$

The set definite times are pure delay times.

Operating times of the definite-time stages

Pickup time/dropout time

Pickup time (in ms) at frequency	50 Hz	60 Hz
7UT612		
Minimum	50	45
Dropout time (in ms), approx.	30	30
7UT613/63x		
Minimum	41	34
Dropout time (in ms), approx.	23	20

Dropout ratios

Current stages	Approx. 0.95 for $I_2/I_N \geq 0.5$

Thermal overload protection

Overload protection using a thermal replica

Multiple availability		2 times (option)	
Setting ranges			
Factor k acc. IEC 60255-8		0.10 to 4.00	(steps 0.01)
Time constant	τ	1.0 to 999.9 min	(steps 0.1 min)
Cooling down factor at motor stand-still (for motors)	$K\tau$-factor	1.0 to 10.0	(steps 0.1)
Thermal alarm stage	$\Theta_{alarm}/\Theta_{trip}$	50 to 100 % referred to trip temperature rise	(steps 1 %)
Current-based alarm stage	I_{alarm}	0.10 to 4.00 A [1]	(steps 0.01 A)
Start-up recognition (for motors)	$I_{start-up}$	0.60 to 10.00 A [1] or deactivated (no start-up recognition)	(steps 0.01 A)
Emergency start run-on time (for motors)	T_{run-on}	10 to 15000 s	(steps 1 s)

Overload protection using a thermal replica (cont'd)

Tripping characteristics

Tripping characteristic for $I/(k \cdot I_N) \leq 8$

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

t	Tripping time
τ	Heating-up time constant
I	Actual load current
I_{pre}	Preload current
k	Setting factor IEC 60255-8
I_N	Rated current of the protected object

Dropout ratios

Θ/Θ_{trip}	Dropout at Θ_{alarm}
Θ/Θ_{alarm}	Approx. 0.99
I/I_{alarm}	Approx. 0.97

Tolerances
(with one 3-phase measuring location)

Referring to k · I_N	3 % or 10 mA [1]; class 3 % acc. IEC 60255-8
Referring to tripping time	3 % or 1 s at $f_N = 50/60$ Hz for $I/(k \cdot I_N) > 1.25$

Frequency influence referring to k · I_N

In the range $0.9 \leq f/f_N \leq 1.1$	1 % at $f_N = 50/60$ Hz

Hot-spot calculation and determination of the ageing rate

Thermo-box
(temperature monitoring box)

Number of measuring points	From 1 thermo-box (up to 6 temperature sensors) or from 2 thermo-boxes (up to 12 temperature sensors)

For hot spot calculation *one* temperature sensor must be connected.

Cooling

Cooling method		ON (oil natural) OF (oil forced) OD (oil directed)	
Oil exponent	Y	1.6 to 2.0	(steps 0.1)
Hot spot to top-oil gradient H_{gr}		22 to 29	(steps 1)

Annunciation thresholds

Warning temperature hot spot	98 to 140 °C 208 to 284 °F	(steps 1 °C) (steps 1 °F)
Alarm temperature hot spot	98 to 140 °C 208 to 284 °F	(steps 1 °C) (steps 1 °F)
Warning ageing rate	0.125 to 128.000	(steps 0.001)
Alarm ageing rate	0.125 to 128.000	(steps 0.001)

1) Secondary values based on $I_N = 1$ A;
for $I_N = 5$ A they must be multiplied by 5.

8

Technical data

Thermo-boxes for overload protection	
Thermo-boxes (connectable)	1 or 2
Number of temperature sensors per thermo-box	Max. 6
Measuring type	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Annuciation thresholds	
For each measuring point:	
Warning temperature (stage 1)	-50 to 250 °C (steps 1 °C) -58 to 482 °F (steps 1 °F) or deactivated (no warning)
Alarm temperature (stage 2)	-50 to 250 °C (steps 1 °C) -58 to 482 °F (steps 1 °F) or deactivated (no alarm)

Breaker failure protection		
Multiple availability	2 times (option)	
Setting ranges		
Current flow monitoring	0.04 to 1.00 A [1)] (steps 0.01 A) for the respective side	
Dropoff to pickup ratio	Approx. 0.9 for $I \geq 0.25$ A [1)]	
Pickup tolerance	5 % of set value or 0.01 A [1)]	
Breaker status monitoring	Binary input for CB auxiliary contact	
Starting conditions		
For breaker failure protection	Internal trip External trip (via binary input)	
Times		
Pickup time	Approx. 2 ms (7UT613/63x) and approx. 3 ms (7UT612) with measured quantities present; Approx. 20 ms after switch-on of measured quantities, f_N = 50/60 Hz	
Reset time (incl. output relay), approx.	50 Hz	60 Hz
7UT612	30 ms	30 ms
7UT613/63x	25 ms	25 ms
Delay times for all stages	0.00 to 60.00 s; deactivated (steps 0.01 s)	
Time tolerance	1 % of setting value or 10 ms	

Overexitation protection (Volt / Hertz) (7UT613 / 633 only)		
Setting ranges		
Pickup threshold alarm stage	1 to 1.2 (steps 0.01)	
Pickup threshold V/f>>-stage	1 to 1.4 (steps 0.01)	
Time delays T	0 to 60 s (steps 0.01 s) or deactivated	
Characteristic values of V/f and assigned times t (V/f)	1.05/1.1/1.15/1.2/1.25/1.3/1.35/1.4 0 to 20000 s (steps 1 s)	
Cooling down time $T_{Cooling}$	0 to 20000 s (steps 1 s)	
Times (in ms) (alarm and V/f>>-stage)	50 Hz	60 Hz
Pickup times at 1.1 of set value, approx.	36	31
Drop-off times, approx.	28	23
Drop-off ratio (alarm, trip)	0.95	
Tolerances		
V/f-Pickup	3 % of set value	
Time delays T	1 % or 10 ms	
Thermal characteristic (time)	5 % rated to V/f or 600 ms	

1) Secondary values based on I_N = 1 A;
for I_N = 5 A they must be multiplied by 5.

Undervoltage protection (definite-time and inverse-time function) (ANSI 27)	
Setting range	
Undervoltage pickup V<, V<<, V_p< (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time multiplier T_M	0.1 to 5 s (steps 0.01 s)
Times	
Pickup time V<, V<<	Approx. 50 ms
Drop-off time V<, V<<	Approx. 50 ms
Drop-off ratio V<, V<<, V_p<	1.01 or 0.5 V
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms
Inverse-time characteristic	1 % of measured value of voltage

Overvoltage protection (ANSI 59)	
Setting ranges	
Overvoltage pickup V>, V>> (maximum phase-to-phase voltage or phase-to-earth-voltage)	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times V>, V>>	Approx. 50 ms
Drop-off times V>, V>>	Approx. 50 ms
Drop-off ratio V>, V>>	0.9 to 0.99 (steps 0.01)
Tolerances	
Voltage limit value	1 % of set value 0.5 V
Time delays T	1 % or 10 ms

Frequency protection (ANSI 81)	
Setting ranges	
Steps; selectable f>, f<	4
Pickup values f>, f<	40 to 65 Hz (steps 0.01 Hz)
Time delays T	3 stages 0 to 100 s, 1 stage up to 600 s (steps 0.01 s)
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Times	
Pickup times f>, f<	Approx. 100 ms
Drop-off times f>, f<	Approx. 100 ms
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio V_1<	Approx. 1.05
Tolerances	
Frequency	10 mHz (at V> 0.5 V_N)
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Reverse-power protection (ANSI 32R)	
Setting ranges	
Reverse power $P_{Rev.}$>/S_N	- 0.5 to - 30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.}$>	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.}$>	0.25 % S_N ± 3 % set value
Time delays T	1 % or 10 ms

Technical data

Forward-power protection (ANSI 32F)	
Setting ranges	
Forward power $P_{Forw.<}/S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{Forw.>}/S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{Forw.<}$	1.1 or 0.5 % of S_N
Drop-off ratio $P_{Forw.>}$	Approx. 0.9 or – 0.5 % of S_N
Tolerances	
Active power $P_{Forw.<}$, $P_{Forw.>}$	0.25 % S_N ± 3 % of set value at $Q < 0.5\ S_N$ at accurate measuring 0.5 % S_N ± 3 % of set value at $Q < 0.5\ S_N$ at fast measuring
Time delays T	1 % or 10 ms

External trip commands	
Binary inputs	
Number of binary inputs for direct tripping	2
Operating time	Approx. 12.5 ms min. Approx. 25 ms typical
Dropout time	Approx. 25 ms
Delay time	0.00 to 60.00 s (steps 0.01 s)
Expiration tolerance	1 % of set value or 10 ms
The set definite times are pure delay times.	
Transformer annunciations	
External annunciations	Buchholz warning Buchholz tank Buchholz tripping

Measured quantities supervision	
Current symmetry (for each measurement location) BAL. FAKT. I BAL. I LIMIT	$\lvert I_{min}\rvert$ / $\lvert I_{max}\rvert$ < BAL. FAKT. I if I_{max} / I_N > BAL. I LIMIT / I_N 0.10 to 0.90 (steps 0.01) 0.10 to 1.00 A [1)] (steps 0.01 A)
Voltage symmetry (if voltages applied)	$\lvert V_{min}\rvert / \lvert V_{max}\rvert$ < BAL. FAKT. if $\lvert V_{max}\rvert$ > BALANCE V-LIMIT
Voltage sum (if voltages applied)	$\lvert \underline{V}_{L1}+\underline{V}_{L2}+\underline{V}_{L3}- kV \cdot \underline{V}_{EN}\rvert > 25$ V
Current phase sequence	$\underline{I}_{L1}$ before $\underline{I}_{L2}$ before $\underline{I}_{L3}$ (clockwise) or $\underline{I}_{L1}$ before $\underline{I}_{L3}$ before $\underline{I}_{L2}$ (counter-clockwise) if $\lvert\underline{I}_{L1}\rvert, \lvert\underline{I}_{L2}\rvert, \lvert\underline{I}_{L3}\rvert > 0.5\ I_N$
Voltage phase sequence (if voltages applied)	$\underline{V}_{L1}$ before $\underline{V}_{L2}$ before $\underline{V}_{L3}$ (clockwise) or $\underline{V}_{L1}$ before $\underline{V}_{L3}$ before $\underline{V}_{L2}$ (counter-clock) if $\lvert\underline{V}_{L1}\rvert, \lvert\underline{V}_{L2}\rvert, \lvert\underline{V}_{L3}\rvert > 40\ V/\sqrt{3}$
Broken wire	Unexpected instantaneous current value and current interruption or missing zero crossing

Fuse failure monitor	
	detects failure of the measured voltage

Trip circuit supervision	
Trip circuits	
Number of supervised trip circuits	1
Operation of each trip circuit	With 1 binary input or with 2 binary inputs

Flexible protection functions (ANSI 27, 32, 47, 50, 55, 59,81)	
N°. of selectable stages	12
Operating modes / measuring quantities	Measurement location or side selectable
3-phase	$I, I_1, I_2, 3I_0, V, V_1, V_2, V_0, P, Q, \cos\varphi$
1-phase	$I, I_E, I_{E\ sens.}, V, P, Q, \cos\varphi$
Without fixed phase relation	f, binary input
Pickup when	Exceeding or falling below threshold value
Setting ranges	
Current $I, I_1, I_2, 3I_0, I_E$	0.05 to 35 A (steps of 0.01 A)
Sens. earth curr. $I_{E\ sens.}$	0.001 to 1.5 A (steps of 0.001 A)
Voltages V, V_1, V_2, V_0	1 to 170 V (steps of 0.1 V)
Displacement voltage V_E	1 to 200 V (steps of 0.1 V)
Power P, Q	1.6 to 3000 W (steps of 0.1 W)
Power P, Q (side)	0.01 to 17 P/S_N, Q/S_N, (steps of 0.01)
Power factor ($\cos\varphi$)	- 0.99 to + 0.99 (steps of 0.01)
Frequency f_N = 50/60 Hz	10 to 66 Hz (steps of 0.01 Hz)
Pickup delay time	0 to 60 s (steps of 0.01 s)
Trip delay time	0 to 3600 s (steps of 0.01 s)
Dropout delay time	0 to 60 s (steps of 0.01 s)
Times	On request (see Manual)
Dropout times	On request (see Manual)
Tolerances	On request (see Manual)

Additional functions	
Operational measured values	
– Operational measured values of currents, 3-phase for each side and measurement location	I_{L1}; I_{L2}; I_{L3} in A primary and secondary and % of I_N
Tolerance at I_N = 1 or 5 A	1 % of measured value or 1 % of I_N
Tolerance at I_N = 0.1 A	2 % of measured value or 2 % of I_N
– Operational measured values of currents, 3-phase for each side and measurement location	$3I_0$; I_1; I_2 in A primary and secondary and % of I_N
Tolerance	2 % of measured value or 2 % of I_N
– Operational measured values of currents	
1-phase for each measurement location	in A primary and secondary and % of I_N
Tolerance at I_N = 1 or 5 A	1 % of measured value or 1 % of I_N
Tolerance at I_N = 0.1 A	2 % of measured value or 2 % of I_N
For high-sensitivity inputs	in A primary and secondary
Tolerance	1 % of measured value or 2 mA

	Feeder	Further	High-sensitivity
7UT612	I_1 to I_7	I_7 to I_8	I_8
7UT613	I_1 to I_9	I_{x1} to I_{x3}	I_{x3}
7UT633	I_1 to I_9	I_{x1} to I_{x3}	I_{x3}
7UT635	I_1 to I_{12}	I_{x1} to I_{x4}	I_{x3}, I_{x4}

– Phase angles of currents, 3-phase for each measurement location	φ (I_{L1}); φ (I_{L2}); φ (I_{L3}) in °, referred to φ (I_{L1})
Tolerance	1 ° at rated current

8

Technical data

Operational measured values *(cont'd)*	
– Phase angles of currents, 7UT612 7UT613 7UT633 7UT635	 φ (I_1) to φ (I_8) φ (I_1) to φ (I_9), φ (I_{x1}) to φ (I_{x3}) φ (I_1) to φ (I_9), φ (I_{x1}) to φ (I_{x4}) φ (I_1) to φ (I_{12}), φ (I_{x1}) to φ (I_{x4})
1-phase for each measurement location Tolerance	in °, referred to φ (I_1) 1 ° at rated current
– Operational measured values of voltages (7UT613/633 only)	in kV primary and V secondary and % of V_N
3-phase (if voltage applied) Tolerance Tolerance 1-phase (if voltage applied) Tolerance	V_{L1-E}, V_{L2-E}, V_{L3-E}, V_{L1-L2}, V_{L2-L3}, V_{L3-L1}, 0.2 % of measured value or ± 0.2 V V_1, V_2, V_0, 0.4 % of measured value or ± 0.4 V V_{EN} or V_4 0.2 % of measured value or ± 0.2 V
– Phase angles of voltages (7UT613/633 only, if voltages applied) Tolerance	φ (V_{L1-E}), φ (V_{L2-E}), φ (V_{L3-E}), φ (V_4), φ (V_{EN}) 1 ° at rated voltage
– Operational measured values of frequency Range Tolerance	f in Hz and % of f_N 10 to 75 Hz 1 % within range f_N ± 10 % and $I \geq I_N$
– Operational measured values of power	S / P / Q 7UT612: x / – / – 7UT613: x / x / x 7UT633: x / x / x 7UT635: x / – / –
S (apparent power)	Applied or rated voltage
P (active power)	Only if voltage applied, 7UT613/633 only
Q (reactive power)	Only if voltage applied, 7UT613/633 only, in kVA; MVA; GVA primary
– Operational measured value of power factor	cos φ (p.f.) Only if voltage applied, 7UT613/633 only
– Overexcitation Tolerance	V / f Only if voltage applied, 7UT613/633 only 2 % of measured value
– Operational measured values for thermal value	Θ_{L1}; Θ_{L2}; Θ_{L3}; Θ_{res}, referred to tripping temperature rise Θ_{trip}
– Operational measured values (Overload protection acc. to IEC 60354)	$\Theta_{thermo\text{-}box1}$ to $\Theta_{thermo\text{-}box12}$ in °C or °F relative aging rate, load reserve
– Measured values of differential protection Tolerance (with preset values)	$I_{DIFF\ L1}$; $I_{DIFF\ L2}$; $I_{DIFF\ L3}$; $I_{REST\ L1}$; $I_{REST\ L2}$; $I_{REST\ L3}$ in % of operational rated current 2 % of measured value or 2 % of I_N (50/60 Hz) 3 % of measured value or 3 % of I_N (16.7 Hz)
– Measured values of restricted earth-fault protection Tolerance (with preset values)	$I_{DIFFREF}$; $I_{RestREF}$ in % of operational rated current 2 % of measured value or 2 % of I_N (50/60 Hz) 3 % of measured value or 3 % of I_N (16.7 Hz)

Max. / Min. / Mean report	
Report of measured values	With date and time from all sides and measurement locations
Reset, automatic	Time of day adjustable (in minutes, 0 to 1439 min) Time frame and starting time adjustable (in days, 1 to 365 days, and ∞)
Reset, manual	Using binary input, using keypad, via communication
Min./max./mean values for current	I_{L1}, I_{L2}, I_{L3}, I_1 (positive-sequence component) I_2 (negative-sequence component), $3I_0$, $I_{DIFF\ L1}$, $I_{DIFF\ L2}$, $I_{DIFF\ L3}$, $I_{RESTR.L1}$, $I_{RESTR.L2}$, $I_{RESTR.L3}$
Min./max./mean values for voltages	V_{L1-E}, V_{L2-E}, V_{L3-E} V_1 (positive-sequence component) V_2 (negative-sequence component) V_0, V_E, V_{L1-L2}, V_{L2-L3}, V_{L3-L1}
Min./max./mean values for power	S, P, Q, cos φ, frequency
Min./max. for mean values	see above
Fault event log	
Storage of the messages of the last 8 faults	With a total of max. 200 messages
Fault recording	
Number of stored fault records	Max. 8
Storage period (start with pickup or trip)	Max. 5 s for each fault, Approx. 5 s in total

	7UT 612	613	633	635
Sampling rate at f_N = 50 Hz	600 Hz	800 Hz	800 Hz	800 Hz
Sampling rate at f_N = 60 Hz	720 Hz	960 Hz	960 Hz	960 Hz

Switching statistics	
Number of trip events caused by 7UT6	
Total of interrupted currents caused by 7UT6	Segregated for each pole, each side and each measurement location
Operating hours Criterion	Up to 7 decimal digits Excess of current threshold
Real-time clock and buffer battery	
Resolution for operational messages	1 ms
Resolution for fault messages	1 ms
Buffer battery	3 V/1 Ah, type CR 1/2 AA Self-discharging time approx. 10 years
Time synchronization	
Operating modes:	
Internal	Internal via RTC
IEC 60870-5-103	External via system interface (IEC 60870-5-103)
Time signal IRIG B	External via IRIG B
Time signal DCF77	External, via time signal DCF77
Time signal synchro-box	External, via synchro-box
Pulse via binary input	External with pulse via binary input

8

Selection and ordering data

Description	Order No.	Order Code
7UT612 differential protection relay for transformers, generators, motors and busbars Housing 1/3 x 19"; 3 BI, 4 BO, 1 live status contact, 7 I, I_{EE}[1)]	*7UT612□-□□□□□-□□A0*	*□□□*
Rated current		
I_N = 1 A	1	
I_N = 5 A	5	
Rated auxiliary voltage (power supply, binary inputs)		
24 to 48 V DC, binary input threshold 17 V [2)]	2	
60 to 125 V DC [3)], binary input threshold 17 V [2)]	4	
110 to 250 V DC, 115/230 V AC, binary input threshold 73 V [2)]	5	
Unit design		
For panel surface mounting, two-tier terminals on top and bottom	B	
For panel flush mounting, plug-in terminals (2/3-pole AMP connector)	D	
For panel flush mounting, screw-type terminals, (direct wiring/ring lugs)	E	
Region-specific default settings/function and language settings		
Region DE, 50/60 Hz, IEC/ANSI, language German; selectable	A	
Region World, 50/60 Hz, IEC/ANSI, language English (GB); selectable	B	
Region US, 60/50 Hz, ANSI/IEC, language English (US); selectable	C	
Region World, 50/60 Hz, IEC/ANSI, language Spanish; selectable	E	
System interface (Port B) on rear		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single loop, ST connector[4)]	5	
PROFIBUS-FMS Slave, optical, double loop, ST connector[4)]	6	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm, double loop, ST connector[4)]	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector[4)]	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector[4)]	9	L 0 H

See next page

1) Sensitivity selectable normal/high.
2) The binary input thresholds are selectable in two stages by means of jumpers.
3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
4) With surface-mounting housing: only RS485 interface available.

Selection and ordering data

Description	Order No.
7UT612 differential protection relay for transformers, generators, motors and busbars	*7UT612□ - □□□□□-□□A0*
DIGSI 4/browser/modem interface (Port C) on rear/temperature monitoring box connection	
No DIGSI 4 port	*0*
DIGSI 4/browser, electrical RS232	*1*
DIGSI 4/browser or temperature monitoring box[1)], electrical RS485	*2*
DIGSI 4/browser or temperature monitoring box[1)], 820 nm fiber optic, ST connector	*3*
Functions	
Measured values/monitoring functions	
Basic measured values	*1*
Basic measured values, transformer monitoring functions (connection to thermo-box/hot spot acc. to IEC, overload factor)	*4*
Differential protection + basic functions	
Differential protection for transformer, generator, motor, busbar (87) Overload protection for one winding (49), Lockout (86) Overcurrent-time protection (50/51): $I>$, $I>>$, I_P (inrush stabilization) Overcurrent-time protection (50N/51N): $3I_0>$, $3I_0>>$, $3I_{0P}$ (inrush stabilization) Overcurrent-time protection earth (50G/51G): $I_E>$, $I_E>>$, I_{EP} (inrush stabilization)	*A*
Differential protection + basic functions + additional functions	
Restricted earth fault protection, low impedance (87N) Restricted earth fault protection, high impedance (87N without resistor and varistor), O/C 1-phase Trip circuit supervision (74TC), breaker failure protection (50BF), unbalanced load protection (46) High-sensitivity overcurrent-time protection/tank leakage protection (64), O/C 1-phase	*B*

1) External temperature monitoring box required.

Selection and ordering data

Description	Order No.	Order Code
7UT613 differential protection relay for transformers, generators, motors and busbars Housing 1/2 x 19"; 5 BI, 8 BO, 1 live status contact, 11 I, I_{EE} 1)	*7UT613□-□□□□□-□□□□ □□□*	
Rated current		
I_N = 1 A	*1*	
I_N = 5 A	*5*	
Rated auxiliary voltage (power supply, binary inputs)		
24 to 48 V DC, binary input threshold 17 V 2)	*2*	
60 to 125 V DC 3), binary input threshold 17 V 2)	*4*	
110 to 250 V DC 1), 115/230 V AC, binary input threshold 73 V 2)	*5*	
110 to 250 V DC 1), 115/230 V AC, binary input threshold 154 V 2)	*6*	
Unit design		
Surface-mounting housing with two-tier terminals	*B*	
Flush-mounting housing with plug-in terminals	*D*	
Flush-mounting housing with screw-type terminals	*E*	
Region-specific default settings/language settings		
Region DE, 50/60 Hz, IEC/ANSI, language German; selectable	*A*	
Region World, 50/60 Hz, IEC/ANSI, language English (GB); selectable	*B*	
Region US, 60/50 Hz, ANSI/IEC, language English (US); selectable	*C*	
Region World, 50/60 Hz, IEC/ANSI, language French; selectable	*D*	
Region World, 50/60 Hz, IEC/ANSI, language Spanish; selectable	*E*	
System interface (Port B) on rear		
No system interface	*0*	
IEC 60870-5-103 protocol, electrical RS232	*1*	
IEC 60870-5-103 protocol, electrical RS485	*2*	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
PROFIBUS-FMS Slave, electrical RS485	*4*	
PROFIBUS-FMS Slave, optical, single ring, ST connector 4)	*5*	
PROFIBUS-FMS Slave, optical, double ring, ST connector 4)	*6*	
PROFIBUS-DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector 4)	*9*	*L 0 B*
MODBUS, electrical RS485	*9*	*L 0 D*
MODBUS, optical 820 nm, ST connector 4)	*9*	*L 0 E*
DNP 3.0, electrical RS485	*9*	*L 0 G*
DNP 3.0, optical 820 nm, ST connector 4)	*9*	*L 0 H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	*9*	*L 0 R*
IEC 61850, 100 Mbit Etherent, optical, double, ST connector (EN 100) 5)	*9*	*L 0 S*

see next page

1) Sensitivity selectable normal/high.

2) The binary input thresholds are selectable in two stages by means of jumpers.

3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

4) With surface-mounting housing: only RS485 interface available.

5) If position 9 = "B" (surface-mounting housing), please order relay with electrical Ethernet interface and use a separate FO switch.

Selection and ordering data

Description	Order No.	Order Code
7UT613 differential protection relay for transformers, generators, motors and busbars	7UT613□-□□□□□ - □□□□	□□□
Port C and Port D		
Port C: DIGSI 4/modem, electrical RS232; Port D: empty	1	
Port C: DIGSI 4/modem/thermo-box, electrical RS485; Port D: empty	2	
Port C and Port D installed	9	M □□
Port C (service interface)		
DIGSI 4/modem, electrical RS232		1
DIGSI 4/modem/thermo-box, electrical RS485		2
Port D (additional interface)		
Thermo-box, optical 820 nm, ST connector		A
Thermo-box, electrical RS485		F
Measured values/monitoring functions		
Basic measured values	1	
Extended measured values, min./max. values, mean values	2	
Extended measured values, min./max., mean values, transformer monitoring functions (connection to thermo-box/hot spot, overload factor)	4	
Differential protection + basic functions		
Differential protection for transformer, generator, motor, busbar (87) Overload protection according to IEC for one side (49) Lock out (86) Overcurrent-time protection phases (50/51): $I>$, $I>>$, I_P (inrush stabilization) Overcurrent-time protection 3 I_0 (50N/51N): 3 $I_0>$, 3 $I_0>>$, 3 I_{0P} (inrush stabilization) Overcurrent-time protection earth (50G/51G): $I_E>$, $I_E>>$, I_{EP} (inrush stabilization)	A	
Differential protection + basic functions + additional current functions		
Restricted earth-fault protection, low impedance (87N) Restricted earth-fault protection, high impedance (87N without resistor and varistor), O/C 1-phase Trip circuit supervision (74TC) Unbalanced load protection (46) Breaker failure protection (50BF) High-sensitivity overcurrent-time protection/tank leakage protection (64), O/C 1-phase	B	
Additional voltage functions		
Without voltage functions	A	
With overexcitation protection and voltage/power/energy/measurement	B	
With overexcitation protection and voltage/power/energy measurement + Over/undervoltage protection (59/27) + Frequency protection (81) + Directional power protection (32R/F) + Fuse failure monitor (60FL)	C	
Additional functions (general)		
Without	0	
Multiple protection functions (50, 51, 50N/G, 87N, 50BF, 49)[1]	1	
Flexible protection functions	2	
Multiple + flexible protection functions	3	

1) Available if selected on position 14.

8

Selection and ordering data

Description	Order No.	Order Code
7UT63□ differential protection relay for transformers, generators, motors and busbars, graphic display	*7UT63□□-□□□□□-□□□□ □□□*	
Housing, inputs and outputs		
Housing 1/1 x 19”, 21 BI, 24 BO, 1 live status contact 12 current inputs (11 I, $I_{EE}$$^{1)}$); 4 voltage inputs (1 x 3-phase + 1 x 1-phase)	3	
Housing 1/1 x 19”, 29 BI, 24 BO, 1 live status contact 16 current inputs (14 I, 2 $I_{EE}$$^{1)}$)	5	
Rated current		
I_N = 1 A	1	
I_N = 5 A	5	
Rated auxiliary voltage (power supply, binary inputs)		
24 to 48 V DC, binary input threshold 17 V$^{2)}$	2	
60 to 125 V DC$^{3)}$, binary input threshold 17 V$^{2)}$	4	
110 to 250 V DC$^{1)}$, 115/230 V AC, binary input threshold 73 V$^{2)}$	5	
110 to 250 V DC$^{1)}$, 115/230 V AC, binary input threshold 154 V$^{2)}$	6	
Unit design		
Surface-mounting with two-tier terminals	B	
Flush-mounting with plug-in terminals	D	
Flush-mounting with screw-type terminals	E	
Surface mounting with two-tier terminals, with 5 high-speed trip contacts	N	
Flush-mounting with plug-in terminals, with 5 high-speed trip contacts	P	
Flush-mounting with screw-type terminals, with 5 high-speed trip contacts	Q	
Region-specific default settings/language settings		
Region DE, 50/60 Hz, IEC/ANSI language German; selectable	A	
Region World, 50/60 Hz, IEC/ANSI language English (GB); selectable	B	
Region US, 60/50 Hz, ANSI/IEC language English (US); selectable	C	
Region World, 50/60 Hz, IEC/ANSI, language French; selectable	D	
Region World, 50/60 Hz, IEC/ANSI language Spanish; selectable	E	
System interface (Port B) on rear		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single ring, ST connector$^{4)}$	5	
PROFIBUS-FMS Slave, optical, double ring, ST connector$^{4)}$	6	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820, double ring, ST connector$^{4)}$	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector$^{4)}$	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector$^{4)}$	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector (EN 100)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector (EN 100)$^{5)}$	9	L 0 S

see next page

1) Sensitivity selectable normal/high.

2) The binary input thresholds are selectable in two stages by means of jumpers.

3) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

4) With surface-mounting housing: only RS485 interface available.

5) If position 9 = “B” (surface-mounting housing), please order relay with electrical Ethernet interface and use a separate FO switch.

Selection and ordering data

Description	Order No.	Order Code
7UT63☐ differential protection relay for transformers, generators, motors and busbars, graphic display	*7UT63☐☐-☐☐☐☐☐-☐☐☐☐ ☐☐☐*	
Port C and Port D		
Port C: DIGSI 4/modem, electrical RS232; Port D: empty	*1*	
Port C: DIGSI 4/modem/thermo-box, electrical RS485; Port D: empty	*2*	
Port C and Port D installed	*9*	*M ☐☐*
Port C (service interface)		
DIGSI 4/modem, electrical RS232		*1*
DIGSI 4/modem/thermo-box, electrical RS485		*2*
Port D (additional interface)		
Thermo-box, optical 820 nm, ST connector		*A*
Thermo-box, electrical RS485		*F*
Measured values/monitoring functions		
Basic measured values	*1*	
Extended measured values, min./max. values, mean values	*2*	
Extended measured values, min./max. values, mean values, transformer monitoring functions (connection to thermo-box/hot spot, overload factor)	*4*	
Differential protection + basic functions		
Differential protection for transformer, generator, motor, busbar (87) Overload protection according to IEC for one side (49) Lock out (86) Overcurrent-time protection phases (50/51): $I>$, $I>>$, I_P (inrush stabilization) Overcurrent-time protection 3 I_0 (50N/51N): 3 $I_0>$, 3 $I_0>>$, 3 I_{0P} (inrush stabilization) Overcurrent-time protection earth (50G/51G): $I_E>$, $I_E>>$, I_{EP} (inrush stabilization)	*A*	
Differential protection + basic functions + additional current functions		
Restricted earth-fault protection, low impedance (87N) Restricted earth-fault protection, high impedance (87N without resistor and varistor), O/C 1-phase Trip circuit supervision (74TC) Unbalanced load protection (46) Breaker failure protection (50BF) High-sensitivity overcurrent-time protection/tank leakage protection (64), O/C 1-phase	*B*	
Additional voltage functions (only with 7UT633)		
Without voltage functions	*A*	
With overexcitation protection and voltage/power/energy/measurement	*B*	
With overexcitation protection and voltage/power/energy measurement + Over/undervoltage protection (59/27) + Frequency protection (81) + Directional power protection (32R/F) + Fuse failure monitor (6FL)	*C*	
Additional functions (general)		
Without	*0*	
Multiple protection functions (50, 51, 50N/G, 87N, 50BF, 49)[1)]	*1*	
Flexible protection functions	*2*	
Multiple + flexible protection functions	*3*	

1) Available if selected on position 14

Accessories

Description		Order No.
DIGSI 4 Software for configuration and operation of Siemens protection relays running under MS Windows (Windows 2000/XP Professional Edition), device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)		
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)		*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)		*7XS5402-0AA00*
Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator		*7XS5403-0AA00*
IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM		*7XS5460-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format) running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.		*7XS5410-0AA00*
Connecting cable Cable between PC/notebook (9-pin connector) and protection relay (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)		*7XV5100-4*
Cable between thermo-box and relay		
- length 5 m / 16.4 ft		*7XV5103-7AA05*
- length 25 m / 82 ft		*7XV5103-7AA25*
- length 50 m / 164 ft		*7XV5103-7AA50*
Voltage transformer miniature circuit-breaker Rated current 1.6 A; Thermal overload release 1.6 A; Overcurrent trip 6 A		*3RV1611-1AG14*
Temperature monitoring box with 6 thermal inputs For SIPROTEC units		
With 6 temperature sensors and	24 to 60 V AC/DC	*7XV5662-2AD10*
RS485 interface	90 to 240 V AC/DC	*7XV5662-5AD10*
Manual for 7UT612 English		*C53000-G1176-C148-1*
Manual for 7UT6 English V4.0		*C53000-G1176-C160-1*
English V4.6		*C53000-G1176-C160-2*

8

Accessories

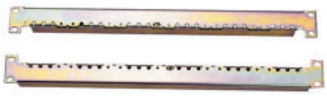


Fig. 8/35 Mounting rail for 19" rack

Fig. 8/36
2-pin connector

Fig. 8/37
3-pin connector

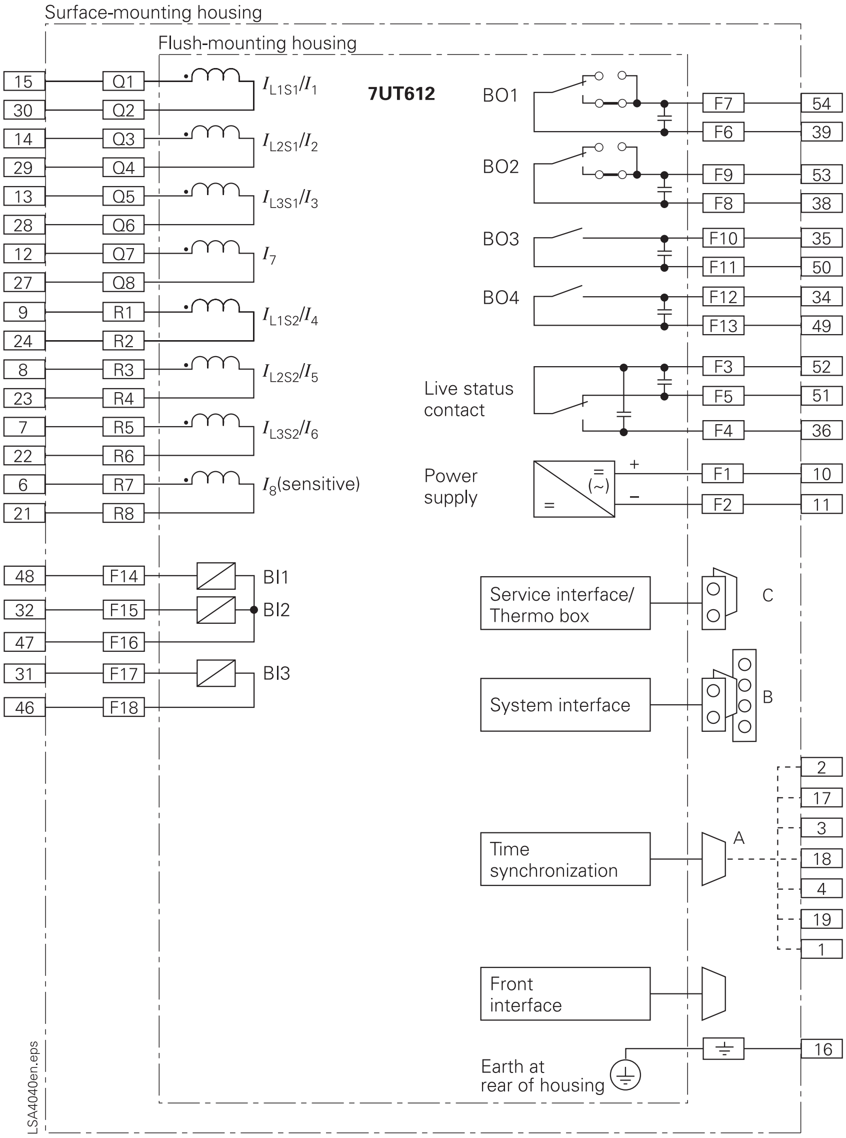
Fig. 8/38
Short-circuit link for
current contacts

Fig. 8/39
Short-circuit link for voltage contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	C73334-A1-C35-1	1	Siemens	8/36
	3-pin	C73334-A1-C36-1	1	Siemens	8/37
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For Type III+	0-539635-1	1	AMP 1)	
	and matching female	0-539668-2		AMP 1)	
	For CI2	0-734372-1	1	AMP 1)	
	and matching female	1-734387-1		AMP 1)	
19" mounting rail		C73165-A63-D200-1	1	Siemens	8/35
Short-circuit links	For current contacts	C73334-A1-C33-1	1	Siemens	8/38
	For voltage contacts	C73334-A1-C34-1	1	Siemens	8/39
Safety cover for terminals	large	C73334-A1-C31-1	1	Siemens	
	small	C73334-A1-C32-1	1	Siemens	

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram



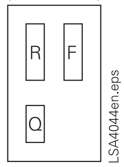
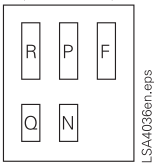


Fig. 8/40 Connection diagram

Connection diagram

Connectors (schematic)



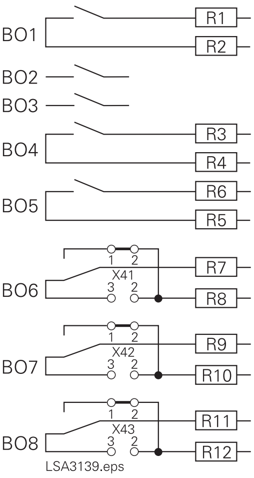


Fig. 8/41a
Additional setting by jumpers:
Separation of common circuit of fast BO1 to BO5 with jumpers X80, X81, X82. Switching of fast BO7, BO8 as NO contact or NC contact with jumpers X41, X42, X43.

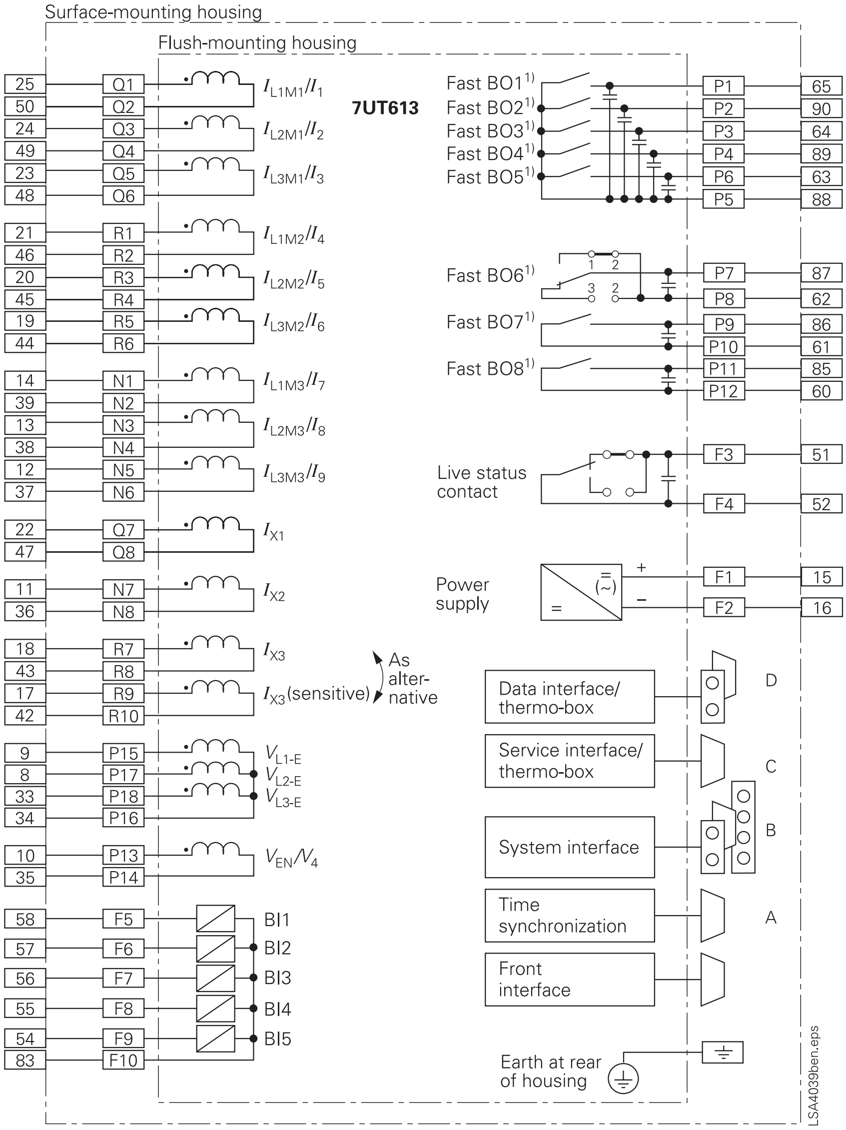
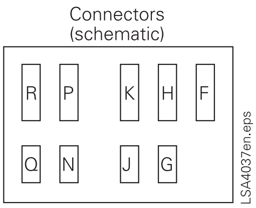


Fig. 8/41 Connection diagram 7UT613

1) Configuration of binary outputs up to hardware-version .../CC
For advanced flexibility see Fig. 8/41a.

Connection diagram



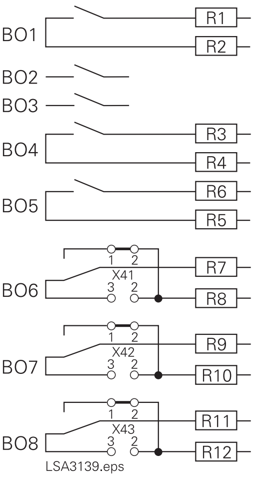


Fig. 8/42a
Additional setting by jumpers:
Separation of common circuit of fast BO1 to BO5 with jumpers X80, X81, X82. Switching of fast BO7, BO8 as NO contact or NC contact with jumpers X41, X42, X43.

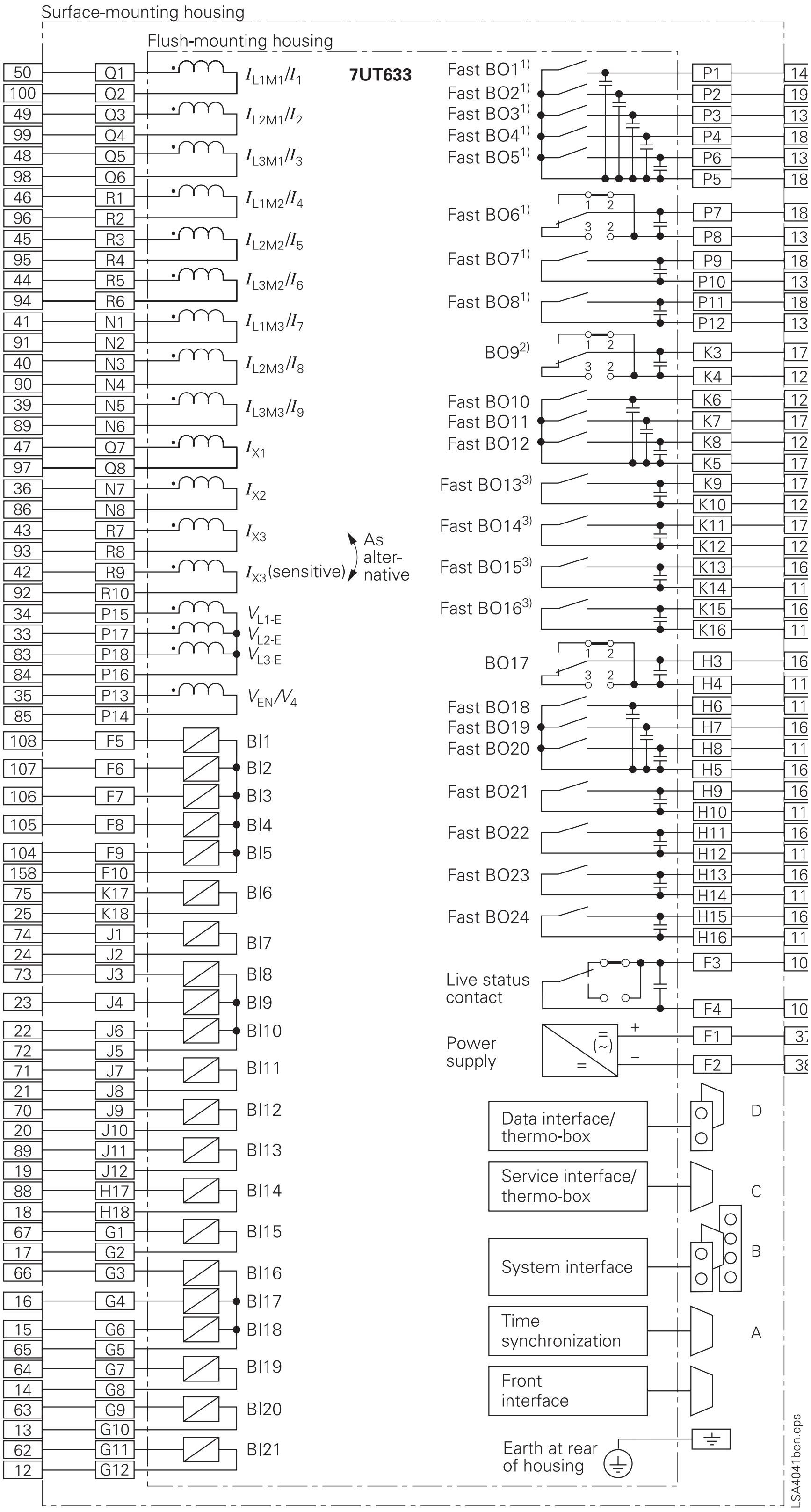
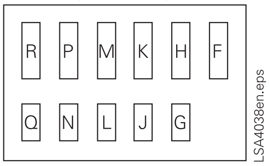


Fig. 8/42 Connection diagram 7UT63

1) Configuration of binary outputs up to hardware-version .../CC
For advanced flexibility see Fig. 8/42a.
2) High-speed contacts (option), NO only
3) High-speed contacts (option)

Connection diagram

Connectors (schematic)



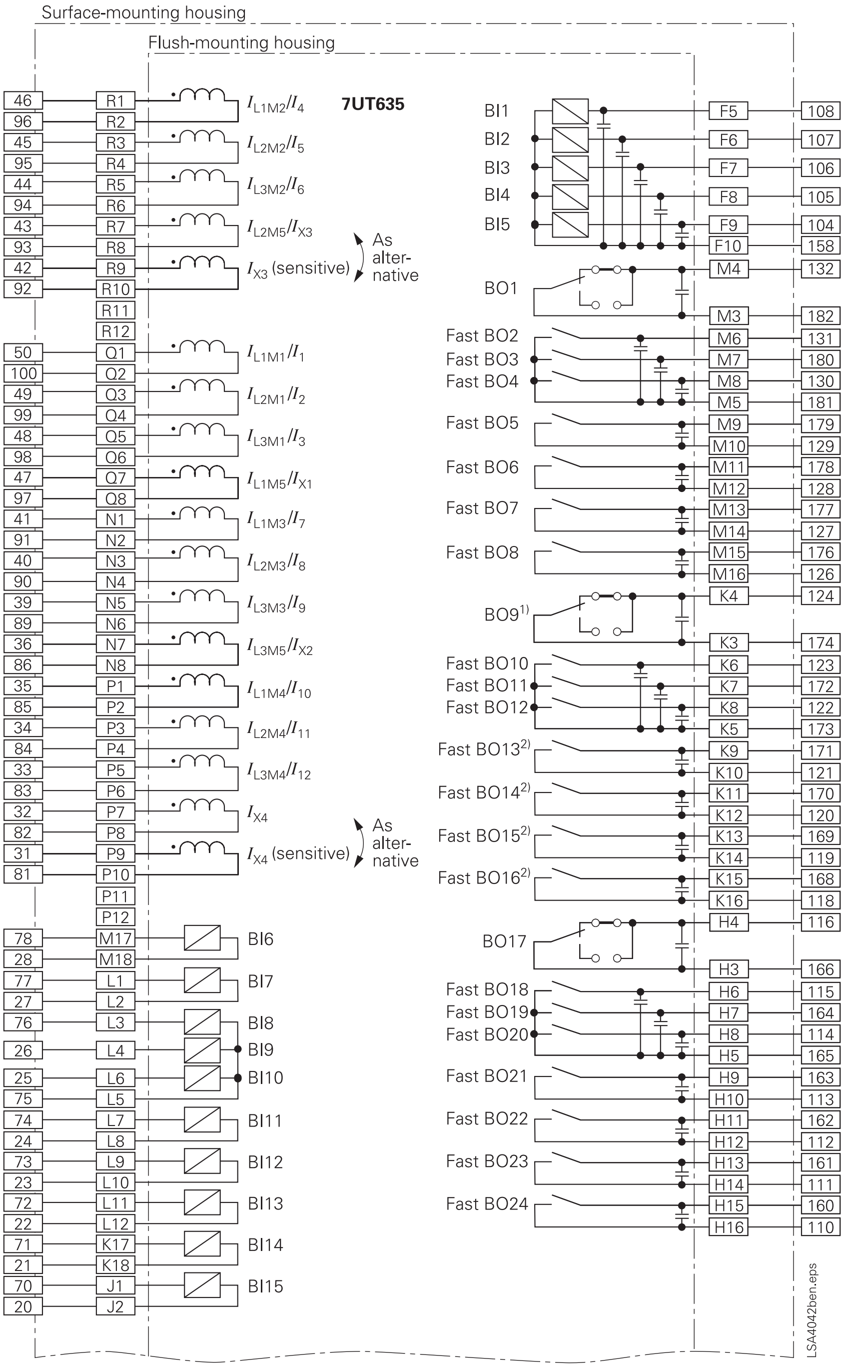


Fig. 8/43 Connection diagram 7UT635
part 1; continued on following page

1) High-speed contacts (option), NO only
2) High-speed contacts (option)

Connection diagram

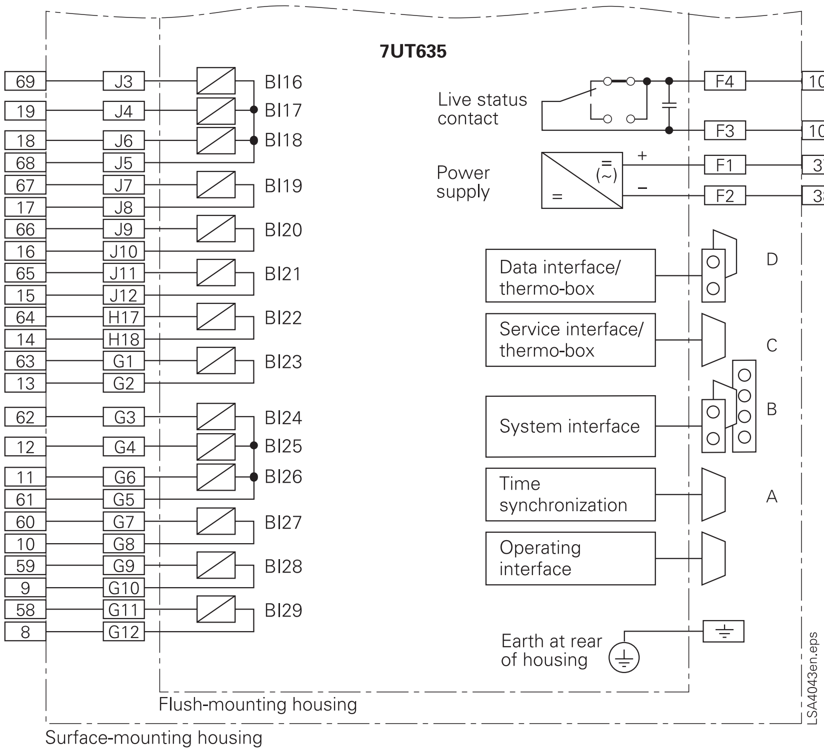


Fig. 8/44 Connection diagram 7UT635 part 2

8

Busbar Differential Protection

Page

SIPROTEC 7SS60
Centralized Numerical Busbar Protection

Fig. 9/1 7SS601 measuring system

Description

The SIPROTEC 7SS60 system is an inexpensive numerical differential current protection for busbars in a centralized configuration.

It is suitable for all voltage levels and can be adapted to a large variety of busbar configurations with an unlimited number of feeders. The components are designed for single busbars, 1½-breaker configurations and double busbars with or without couplers.

The use of matching transformers allows phase-selective measurement. Single-phase measurement can be achieved by using summation current transformers.

Function overview

Features

- Optimized for single busbar and 1½ circuit-breaker configurations
- Suitable for double busbars with or without couplers
- Separate check zone possible
- Short trip times
- Unlimited number of feeders
- Differential current principle
- Low-impedance measuring method
- Numerical measured-value processing
- Suitable for all voltage levels
- Low demands on CTs thanks to additional restraint
- Measured-value acquisition via summation current transformer or phase-selective matching transformers
- Maintained TRIP command (lockout function)
- Centralized, compact design
- Combinative with separate breaker failure protection

Monitoring functions

- Primary current transformers including supply leads
- Operational measured values: Differential and restraint current
- Self-supervision of the relay
- 30 event logs
- 8 fault logs
- 8 oscillographic fault records

Communication interface

- RS485 interface for local and remote operation with DIGSI

Hardware

- Concept of modular components
- Reduced number of module types
- Auxiliary voltage 48 V DC to 250 V DC
- 7SS601 measuring system in 1/6 19-inch housing 7XP20
- Peripheral components in ½ 19-inch housing 7XP20

Front design

- Display for operation and measured values
- 6 LEDs for local indication

Application

The 7SS60 system is an easily settable numerical differential current protection for busbars.

It is suitable for all voltage levels and can be adapted to a large variety of busbar configurations. The components are designed for single busbars, 1½-breaker configurations and double busbars with or without couplers.

The use of matching transformers allows phase-selective measurement.

Single-phase measurement can be achieved by using summation current transformers.

The 7SS60 is designed to be the successor of the 7SS1 static busbar protection. The existing summation current or matching transformers can be reused for this protection system.

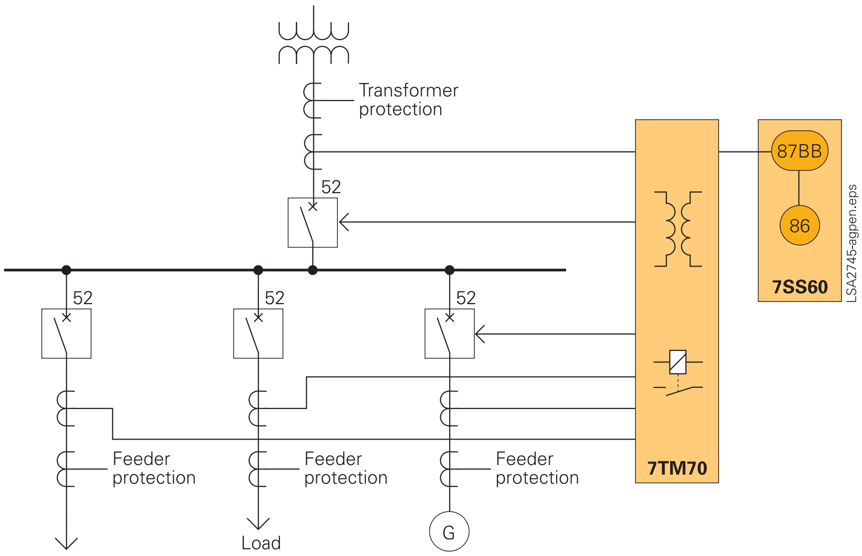


Fig. 9/2 Basic connection scheme 7SS60

Construction/Functions

Design

The 7SS60 compactly-built protection system contains all components for:

- Measured-value acquisition and evaluation
- Operation and LC display
- Annunciation and command output
- Input and evaluation of binary signals
- Data transmission via the RS485 interface with bus capability
- Auxiliary voltage supply

The 7SS60 system comprises the following components:

- 7SS601 measuring system and the peripheral modules
- 7TM70 restraint/command output module
- 7TR71 isolator replica/preference module
- 7TS72 command output module

The number of modules required is determined by the substation configuration and the measuring principle used (summation current transformers or phase-selective measurement). The 7SS601 measuring system is accommodated in a separate housing ($^{1}/_{6}$ 19-inch 7XP20) that is suited for panel flush mounting or cubicle mounting. The 7XP2040 peripheral module housing has a width of ½ 19 inches and can hold up to four peripheral modules. It is suited for panel flush mounting or cubicle mounting and has plug-on connectors fitted at the rear.

The primary current transformers are connected to summation current transformers of type 4AM5120-3DA/4DA or to matching transformers of type 4AM5120-1DA/2DA. With a rated current of 1 or 5 A, the current output at these transformers is 100 mA. This output current is fed onto the 7SS601 measuring system (for differential current formation) and onto the 7TM70 restraint units (for restraint current formation). The summated restraint current is fed onto the 7SS601 measuring system as well.

Functions of the components

- The 7SS601 measuring system comprises:
  - One measuring input for acquisition and processing of the differential and the restraint current
  - 3 binary inputs for acquisition of information, e.g. a blocking condition
  - 2 command relays for activation of other, feeder-specific command relays on the 7TM70 and 7TS72 peripheral modules.

In circuits with summation current transformer, one 7SS601 measuring system is required per protected zone. For phase-selective measurement, one 7SS601 measuring system is required per phase and protected zone.

- 7TM70 restraint/command output module
  This module contains 5 current transformers with rectifiers for the formation of the restraint current. It has also 5 command relays with 2 NO contacts each for output of a direct TRIP command to the circuit-breakers.
- 7TR71 isolator replica/preference module
  This module enables the two bus isolators to be detected in a double busbar. The feeder current is assigned to the corresponding measuring system on the basis of the detected isolator position.
  The module is also designed for an additional function. In the case of a double busbar system, for example, where both bus isolators of a feeder are closed at a time, no selective protection of the two busbars is possible. During this state, one of the two measuring systems is given priority. The module 7TR71 appropriately assigns feeder currents to the corresponding measuring system 7SS601.
  The module also contains an auxiliary relay with two changeover contacts.
- 7TS72 command output module
  The 7TM70 contains 5 trip relays with 2 NO contacts each. If more trip contacts are needed, the 7TS72 module can be used, providing 8 relays with 2 NO contacts each.

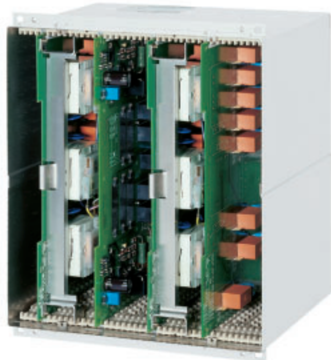


Fig. 9/3 Housing for peripheral modules (front cover removed)

Fig. 9/4 Rear view

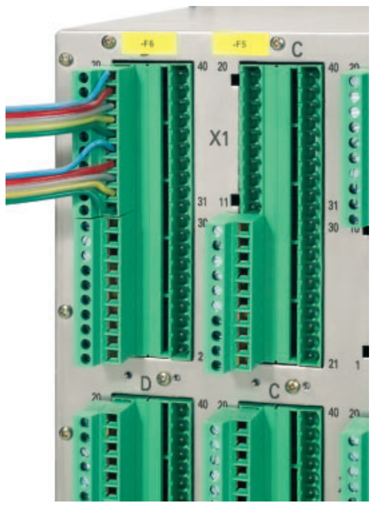


Fig. 9/5 Rear view detail

Protection functions

Measuring principles

The feeder currents can be measured and processed according to different principles.

- Summation current transformer principle
  In the summation current transformer variant, the three secondary currents of the primary CTs are fed onto the three primary windings of the summation current transformers with a ratio of I_{L1}:I_{L2}:I_{L3} = 5:3:4 (winding ratio of n1:n2:n3 = 2:1:3) (see Fig. 9/7: Protection with summation current transformer). This increases significantly the sensitivity to 1-phase faults as compared to 2- or 3-phase faults.
  In view of the fact that the currents involved in such faults are usually low, a sensitivity is achieved that is 1.7 to 2.8 times higher than the fault detection threshold in a symmetrical approach. With a symmetrical, three-phase current of 1 x I_N, the secondary current of the summation current transformers is 100 mA.
  Different primary CT transformation ratios can usually be compensated directly by appropriate selection of the summation CT primary windings. Where the circuit conditions do not allow this, additional matching transformers, such as the 4AM5272-3AA, should be used, preferably in the form of autotransformers (see Fig. 9/8: Protection with summation current transformer and matching transformers). The autotransformer circuit reduces the total burden for the primary CTs.

- Phase-selective measurement
  In this variant, each phase current is measured separately. To do so, each of the secondary currents of the primary transformers is fed onto a matching transformer. This transformer allows, if its primary windings are selected accordingly, to generate a normalized current from a variety of different primary CT transformation ratios (see Fig. 9/9: Phase-selective measurement). With a primary current of 1 x I_N, the secondary current of the matching transformers is 100 mA.

Function principle of the differential protection

The main function of the 7SS60 protection system is a busbar protection that operates with the differential current measuring principle. Its algorithm relies on Kirchhoff's current law, which states that in fault-free condition the vectorial sum I_d of all currents flowing into an independent busbar section must be zero. Some slight deviations from this law may be caused by current transformer error, inaccuracies in the matching of the transformation ratios and measuring inaccuracies. Further errors, which may be due to e.g. transformer saturation in case of high-current external short-circuits, are counteracted by a load-dependent supplementary restraint.

The restraint current I_R is derived from the load condition. This restraint current is formed as the summated magnitudes of all currents. The differential and the restraint current are fed into the 7SS601 measuring system (see Fig. 9/6: Block diagram). With double busbars or sectionalized busbars, one measuring system 7SS601 (summation CT), respectively 3 measuring systems (phase-selective measurement) will be used for each selective section. The module 7TS71 (isolator replica/preference) appropriately assigns feeder currents to the corresponding measuring system 7SS601.

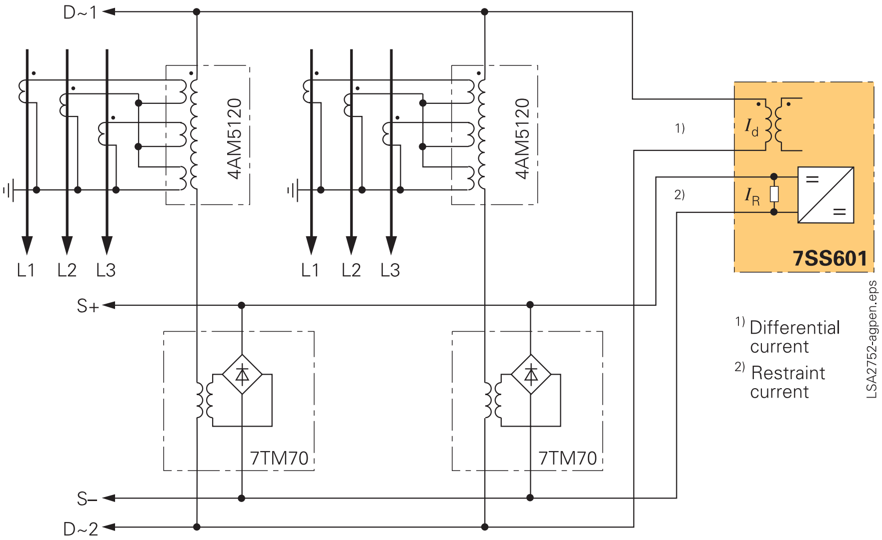


Fig. 9/6 Block diagram: Acquisition of measured values

9

Typical connections

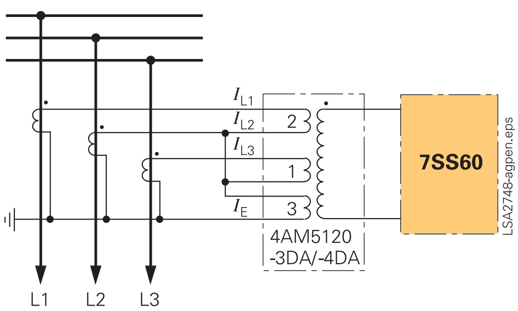


Fig. 9/7 Protection with summation current transformer

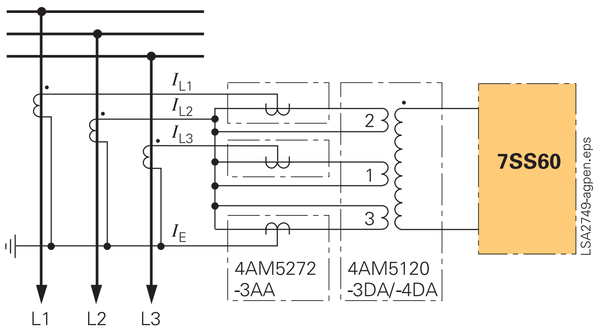


Fig. 9/8 Protection with summation current transformer and matching transformers

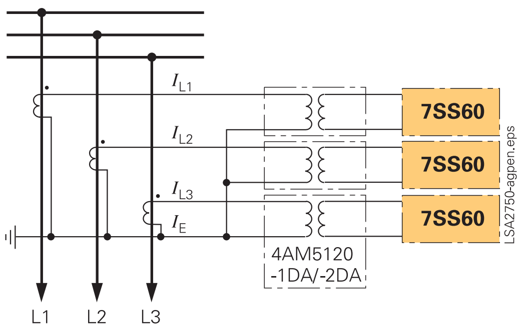


Fig. 9/9 Phase-selective measurement

9

Protection functions/Functions

Pickup characteristic of the differential protection

The characteristic can be set in the parameters for $I_d >$ (pickup value) and for the k factor which considers the linear and non-linear current transformer errors. Differential currents above the set characteristic lead to tripping.

Current transformer monitoring

An independent sensitive differential current monitoring with its parameter $I_{d\ thr}$ detects faults (short-circuits, open circuit) of current transformers and their wiring even with load currents. The affected measuring system is blocked and an alarm is given. By this, the stability of the busbar protection is ensured in case of external faults.

Trip command lockout (with manual reset)

Following a trip of the differential protection, the TRIP command can be kept (sealed-in). The circuit-breakers are not reclosed until the operator has obtained information on the fault; the command must be manually reset by pressing a key or by a binary input.

The logical state of the TRIP command is buffered against a loss of the auxiliary power supply, so that it is still present on restoration of the auxiliary voltage supply.

Test and commissioning aids

The protection system provides user support for testing and commissioning. It has a wide range of integrated aids that can be activated from the keypad or from a PC using the DIGSI program. For some tests a codeword must be entered.
The following test aids are available:

- Display of operational measured values
- Interrogation of status of binary inputs and LED indicators
- Blocking of the TRIP function during testing

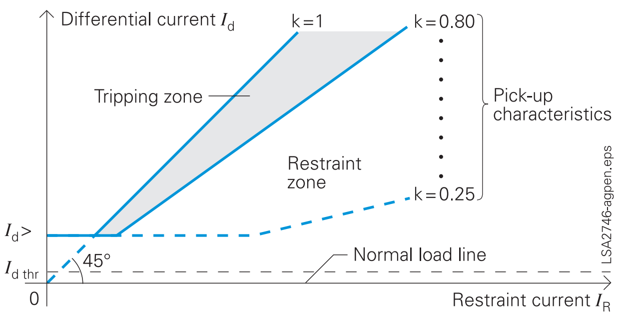


Fig. 9/10 Tripping characteristic

Communication/Functions

Serial data transmission

The device is equipped with an RS485 interface. The interface has bus capability and allows a maximum of 32 units to be connected via a serial two-wire interface. A PC can be connected to the interface via an RS232↔RS485 converter, so that configuration, setting and evaluation can be performed comfortably via the PC using the DIGSI operating program. The PC can also be used to read out the fault record that is generated by the device when a fault occurs.

With RS485↔820 nm optical converters, which are available as accessories (7XV5650, 7XV5651), an interference-free, isolated connection to a control center or a DIGSI-based remote control unit is possible; this allows to design low-cost stations concepts that permit e.g. remote diagnosis.

Comfortable setting

The parameter settings are made in a menu-guided procedure from the integrated operator panel and the LC display. It is, however, more comfortable to use a PC for this purpose, together with the standard DIGSI operating program.

Fault recording

If a fault leads to a trip, a fault record is generated, in which the differential and the restraint current are recorded with a sampling frequency of 2 kHz. In addition, signals are stored as binary traces, which represent internal device states or binary input states. Up to eight fault records can be stored. When a ninth fault occurs, the oldest record is overwritten. A total storage capacity of 7 s is available. The most recent 2.5 s are buffered against power failure.

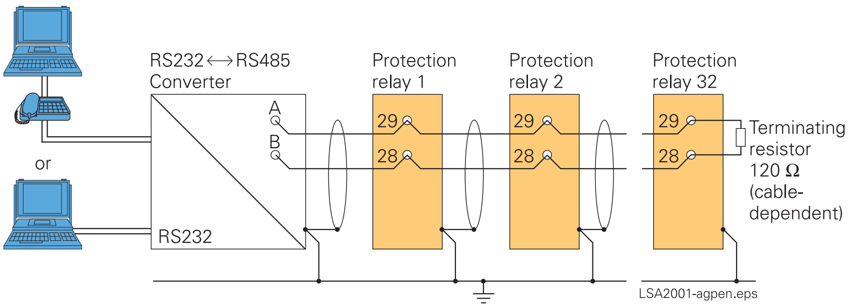


Fig. 9/11 Communication scheme

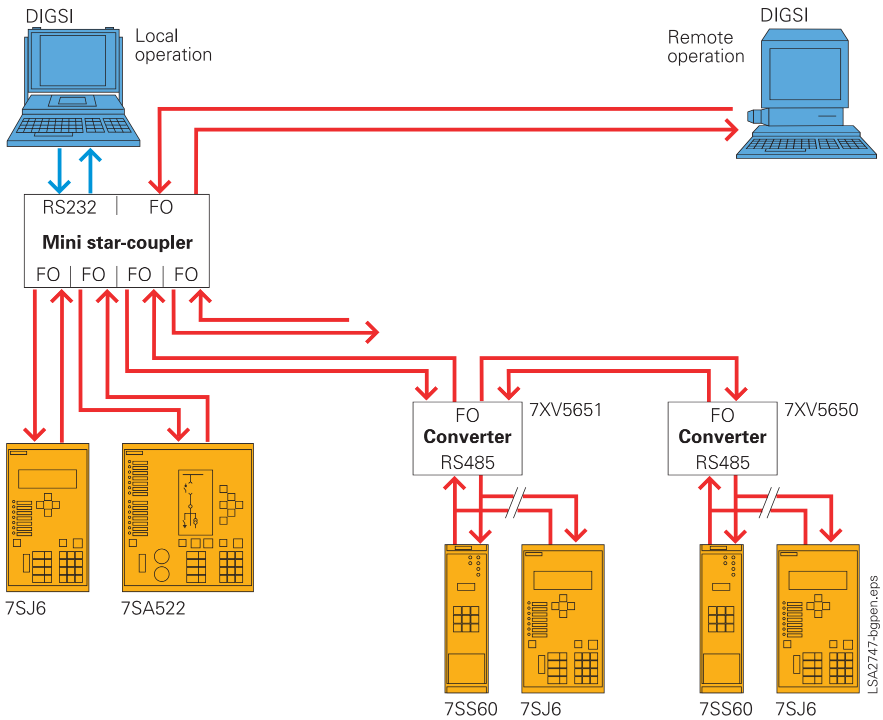


Fig. 9/12 Communication scheme

9

Technical data

7SS60 measuring system		
Measuring input I_d		
Rated current	100 mA	
Rated frequency	50/60 Hz settable, 16.7 Hz	
Dynamic overload capacity (pulse current)	250 x I_N one half cycle	
Thermal overload capacity (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous	
Isolating voltage	2.5 kV (r.m.s.)	
Measuring range for operational measured values	0 to 240 %	
Measuring dynamics	100 x I_N without offset 50 x I_N with full offset	
Measuring input I_R		
Rated current	1.9 mA	
Dynamic overload capability (pulse current)	250 x I_N for 10 ms	
Thermal overload capability (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous	
Isolating voltage	2.5 kV (r.m.s.)	
Measuring dynamics	0 to 200 x I_N	
Auxiliary voltage		
Via integrated DC/DC converter Rated auxiliary voltage V_{aux} (permissible voltage)	24/48 V DC 60/110/125 V DC 220/250 V DC 115 V AC	(19 to 58 V DC) (48 to 150 V DC) (176 to 300 V DC) (92 to 133 V AC)
Superimposed AC voltage (peak-to-peak)	≤ 15 % of rated voltage	
Power consumption	Quiescent Energized	Approx. 3 W Approx. 5 W
Bridging time during failure/ short-circuit of auxiliary voltage	≥ 50 ms at V_{aux} ≥ 100 V DC ≥ 20 ms at V_{aux} ≥ 48 V DC	
Binary inputs		
Number	3 (marshallable)	
Operating voltage range	24 to 250 V DC	
Current consumption when energized	Approx. 2.5 mA Independent of operating voltage	
Pickup threshold	Can be changed by setting jumpers	
Rated aux. voltage 48/60 V DC		
V_{pickup}	≥ 17 V DC	
$V_{drop\text{-}off}$	< 8 V DC	
Rated aux. voltage 110/125/220/250 V DC		
V_{pickup}	≥ 74 V DC	
$V_{drop\text{-}off}$	< 45 V DC	
Max. voltage	300 V DC	

Command contacts	
Number of relays	1 (2 NO contacts) 1 (1 NO contact)
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	
Continuous	5 A
0.5 s	30 A
Signal contacts	
Number of relays	3 (2 marshallable)
Contacts	2 changeover contacts and 1 NO contact (can be changed to NC by jumper)
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	
Continuous	5 A
0.5 s	30 A
Serial interface	
Standard	Isolated RS485
Test voltage	3.5 kV DC
Connection	Data cable at housing terminals, 2 data lines For connection of a personal computer or similar Cables must be shielded, and shields must be earthed.
Transmission rate	As delivered 9600 baud min. 1200 baud, max. 19200 baud
Unit design	
Housing 7XP20	$^1/_6$ 19"
Dimensions	See part 16
Weight	Approx. 4.0 kg
Degree of protection according to IEC 60529-1	
For the unit	IP 51
For operator protection	IP 2X

9

Technical data

Functions	
Differential current protection	
Setting ranges for pickup threshold Differential current I_d> Restraint factor	 0.20 to 2.50 I_{NO} 0.25 to 0.80
Tolerance of pickup value Differential current I_d>	 ± 5 % of setpoint
Minimum duration of trip command	0.01 to 32.00 s (in steps of 0.01 s)
Time delay of trip	0.00 to 10.00 s (in steps of 0.01 s)
Times Minimum tripping time 50/60 Hz[1)] Typical tripping time 50/60 Hz[1)] Minimum tripping time 16.7 Hz[1)] Typical tripping time 16.7 Hz[1)]	 10 ms 12 ms (rapid measurement) 40 ms (repeated measurement) 12 ms 14 ms (rapid measurement) 40 ms (repeated measurement)
Reset time [2)]	28 ms at 50 Hz 26 ms at 60 Hz 70 ms at 16.7 Hz
Differential current supervision Pickup threshold	 0.10 to 1.00 I_{NO}
Lockout function	
Lockout seal-in of trip command	Until reset
Reset	By binary input and/or local operator panel
Additional functions	
Operational measured values Operating currents Measuring range Tolerance	 I_d, I_R 0 to 240 % I_{NO} 5 % of rated value
Fault logging	Buffered storage of the annunciations of the last 8 faults
Time stamping Resolution for operational annunc. Resolution for fault annunciation	 1 ms 1 ms
Fault recording (max. 8 fault)	Buffered against voltage failure (last 2.5 s)
Recording time (from fault detection)	Max. 7.1 s total Pre-trigger and post-fault time can be set
Max. length per record Pre-trigger time Post-fault time Sampling frequency	0.2 to 5.0 s (in steps of 0.01 s) 0.05 to 1.5 s (in steps of 0.01 s) 0.01 to 1.5 s (in steps of 0.01 s) 2 kHz

Peripheral modules	
7TM700 restraint/command output module	
Measuring input I_R	
Number of restraint units	5
Rated current	100 mA
Rated frequency	16.7, 50, 60 Hz
Dynamic overload capacity (pulse current)	250 x I_N one half cycle
Thermal overload capacity (r.m.s.) (where external summation or matching current transformers are used, their limit data must be observed)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
Auxiliary voltage (7TM700)	
Rated auxiliary voltage V_{aux} (permitted voltage range)	48/60 V DC (38 to 72 V DC) 110/125 V DC (88 to 150 V DC) 220/250 V DC (176 to 300 V DC) Settable As delivered: 220/250 V DC
Command contacts (7TM700)	
Number of relays	5
Contacts per relay	2 NO contacts
For short-term operation < 10 s [3)]	
Pickup time	Approx. 7 ms
Switching capacity Make Break	 1000 W/VA 30 W/VA
Switching voltage	250 V AC/DC
Permissible currents Continuous 0.5 s	 5 A 30 A
Weight	Approx. 2.0 kg
7TR710 isolator replica/preferential treatment module	
NOTE: The module 7TR710 can be used to implement 2 different functions: isolator replica or preferential treatment	
Isolator replica	
Number of feeders (single busbar and double busbar)	1
Number of isolators per feeder	2
Preferential treatment	
Number of preferential treatment circuits	2
Number of contacts per preferential treatment	3 changeover contacts
Switching time	< 20 ms
Number of auxiliary relays	1
Contacts of auxiliary relay	2 changeover contacts
Auxiliary voltage	
Rated auxiliary voltage V_{aux} (permissible voltage range)	48/60 V DC (38 to 72 V DC) 110/125 V DC (88 to 150 V DC) 220/250 V DC (176 to 300 V DC) Depending on the design
Relay contacts	
Switching capacity Make Break	 1000 W/VA 30 W/VA
Switching voltage	250 V AC/DC
Permissible current Continuous 0.5 s	 5 A 10 A
Weight	Approx. 0.6 kg

1) Each additional intermediate relay increases the tripping time by 7 ms.
2) Each additional intermediate relay increases the reset time by 8 ms.
3) Limited by the continuous power dissipation of the device.

9

Technical data

Peripheral modules (cont'd)

7TS720 command output module

Auxiliary voltage

Rated auxiliary voltage V_{aux} (permissible voltage range)	48/60 V	(38 to 72 V DC)
	110/125 V	(88 to 150 V DC)
	220/250 V	(176 to 300 V DC)
	Settable As delivered: 220/250 V DC	

Command contacts

Number of relays	8
Contacts per relay	2 NO contacts
For short term operation < 10 s [1)]	
Pickup time	Approx. 7 ms
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V AC/DC
Permissible current	
Continuous	5 A
0.5 s	30 A
Weight	Approx. 0.5 kg

7SS601 measuring system

Current connections (terminals 1 to 6)

Screw-type terminals (ring-type cable lug)	For bolts of 6 mm
Max. outside diameter	13 mm
Type	e.g. PDIG of AMP
For conductor cross-sections of	2.7 to 6.6 mm² AWG 12 to 10
In parallel double leaf-spring-crimp contact for conductor cross-sections of	2.5 to 4.0 mm² AWG 13 to 11
Max. tightening torque	3.5 Nm

Control connections (terminals 7 to 31)

Screw-type terminals (ring-type cable lug)	For 4 mm bolts
Max. outside diameter	9 mm
Type	e.g. PDIG of AMP
For conductor cross-sections of	1.0 to 2.6 mm² AWG 17 to 13
In parallel double leaf-spring-crimp contact for conductor cross-sections of	0.5 to 2.5 mm² AWG 20 to 13
Max. tightening torque	1.8 Nm

1) Limited by the continuous power dissipation of the device.

Connectors with screw-type terminals

Type	COMBICON system of PHOENIX CONTACT Front-MSTB 2.5/10-ST-5.08
For conductor cross-sections of	0.2 to 2.5 mm² (rigid and flexible) AWG 24 to 12 0.25 to 2.5 mm² (with end sleeve)
Multiple conductor connection (2 conductors of same cross-section)	0.2 to 1.0 mm² (rigid) 0.2 to 1.5 mm² (flexible) 0.25 to 1.0 mm² (flexible with end sleeve, without plastic collar) 0.5 to 1.5 mm² (flexible with TWIN end sleeve with plastic collar)
Stripping length	7 mm
Recommended tightening torque	0.5 to 0.6 Nm

Unit design

Housing 7XP204	½ 19"
Dimensions	See part 16
Weight	Approx. 3.5 kg
Degree of protection according to IEC 60529-1	
For the device	IP 51 (front panel) IP 20 (rear)
For the operator protection	IP 2X (if all connectors and blanking plates are fitted)

Matching transformers

4AM5120-1DA00-0AN2

For connection to current transformers with a rated current I_N of		1 A						
Rated frequency f_N		45-60 Hz						
Winding		A-B	B-C	D-E	E-F	G-H	H-J	Y-Z
Number of turns		1	2	4	8	16	32	500
Max. current, continuous	A	6.8	6.8	6.8	6.8	6.8	6.8	0.85
Max. voltage	V	0.4	0.8	1.6	3.2	6.4	12.8	200

4AM5120-2DA00-0AN2

For connection to current transformers with a rated current I_N of		5 A				
Rated frequency f_N		45-60 Hz				
Winding		A-B	B-C	D-E	E-F	Y-Z
Number of turns		1	2	4	8	500
Max. current, continuous	A	26	26	26	26	0.85
Max. voltage	V	0.4	0.8	1.6	3.2	200

Thermal overload capacity

Max. thermal overload capability for all 2 types under simultaneous load of all turns

For 10 s	8 x I_N
For 1 s	20 x I_N

Technical data

Summation current matching transformers

4AM5120-3DA00-0AN2

For connection to current transformers with a rated current I_N of		1 A								
Rated frequency f_N		45-60 Hz								
Winding		A-B	C-D	E-F	G-H	J-K	L-M	N-O	Y-Z	
Number of turns		3	6	9	18	24	36	90	500	
Max. current, continuous	A	4	4	4	4	4	4	2	0.85	
Max. voltage	V	1.2	2.4	3.6	7.2	9.6	14.4	36	200	

4AM5120-4DA00-0AN2

For connection to current transformers with a rated current I_N of		5 A							
Rated frequency f_N		45-60 Hz							
Winding		A-B	C-D	E-F	G-H	J-K	L-M	N-O	Y-Z
Number of turns		1	2	3	4	6	8	12	500
Max. current, continuous	A	17.5	17.5	17.5	17.5	17.5	17.5	8.0	0.85
Max. voltage	V	0.4	0.8	1.2	1.6	2.4	3.2	4.8	200

Thermal overload capability

Max. thermal overload capability for all 2 types under simultaneous load of all turns

For 10 s	8 x I_N
For 1 s	20 x I_N

Electrical tests

Specifications

Standards: IEC 60255-5; ANSI/IEEE C37.90.0

Insulation tests

High voltage test (routine test), measuring input I_d and relay outputs	2.5 kV (r.m.s.); 50 Hz
High voltage test (routine test), auxiliary voltage input and RS485 interface, binary inputs and measuring input I_R	3.5 kV DC
Impulse voltage test (type test), all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses in intervals of 5 s

EMC tests for interference immunity; type tests

Standard	IEC 60255-6, IEC 60255-22 (international product standards) EM 50082-2 (technical generic standard) DIN VDE 57435 part 303 (German product standard for protection devices)
High-frequency test IEC 60255-22-1, DIN 57435 part 303; class III	2.5 kV (peak); 1 MHz; t = 15 ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2; IEC 61000-4-2; class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 (report); class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ENV 50204; class III	10 V/m; 900 MHz; repetition frequency 200 Hz; ED 50 %
Fast transient disturbance/bursts IEC 60255-22-4; IEC 61000-4-4; class III	4 kHz; 5/50 ns; 5 kHz, burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5, installation, class III	Auxiliary voltage: Longitudinal test: 2 kV; 12 Ω; 9 µF Transversal test: 1 kV; 2 Ω; 18 µF Measuring inputs, binary inputs and relay outputs: Longitudinal test: 2 kV; 42 Ω; 0.5 µF Transversal test: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6; class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8; class IV IEC 60255-6	30 A/m; continuous; 300 A/m for 3 s; 50 Hz; 0.5 mT
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz; damped wave; 50 surges per s; duration 2 s; R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per s; both polarities; duration 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 61000-4-12 IEC 60694	2.5 kV (peak, alternating polarity); 100 kHz; 1, 10 and 50 MHz; damped wave; R_i = 50 Ω

EMC tests for interference emission; type test

Standard	EN 50081-* (technical generic standard)
Conducted interference voltage on lines only auxiliary voltage, EN 55022, DIN VDE 0878 part 22, IEC CISPR 22	150 kHz to 30 MHz, limit value, class B
Radio interference field strength EN 55011; DIN VDE 0875 part 11, IEC CISPR 11	30 to 1000 MHz, limit value, class A

9

Technical data

Mechanical stress tests

Vibration, shock stress and seismic vibration

During operation	
Standards	IEC 60255-21-1 IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz, ± 0.075 mm amplitude 60 to 150 Hz; 1 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*; duration 11 ms 3 shocks in each direction of the 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3	Sinusoidal
Horizontal axis	1 to 8 Hz: ± 3.5 mm amplitude 8 to 35 Hz: 1 *g* acceleration
Vertical axis	1 to 8 Hz: ± 1.5 mm amplitude 8 to 35 Hz: 0.5 *g* acceleration
	Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude 8 to 150 Hz: 2 *g* acceleration sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*; duration 11 ms 3 shocks in each direction of the 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*; duration 16 ms 1000 shocks in each direction of the 3 orthogonal axes

Climatic stress test

Temperatures	
Standards	IEC 60255-6
Permissible ambient temperatures – In service	-20 to +45/55 °C
– During storage	-25 to +55 °C
– During transport	-25 to +70 °C
Storage and transport with standard works packing	
Humidity	
Standards	IEC 60068-2-3
Permissible humidity It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 30 days in the year up to 95 % relative humidity; condensation not permissible!

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.
Centralized numerical busbar protection 7SS60 *Measuring system 50, 60, 16.7 Hz*	*7SS601□-□□A□0-0AA0*
Rated current/frequency	
100 mA; 50/60 Hz AC	0
100 mA; 16.7 Hz AC	6
Rated auxiliary voltage	
24 to 48 V DC	2
60 to 125 V DC	4
220 to 250 V DC	5
Unit design	
Housing 7XP20 1/6 19-inch, for panel flush mounting or cubicle mounting	E
Measuring system	
Standard	0
Stabilizing/command output module 5 stabilizing CTs, 5 relays with 2 NO contacts 48/60 V DC, 110/125 V DC, 220/250 V DC settable	*7TM7000-0AA00-0AA0*
Isolator replica/preference module	*7TR7100-□AA00-0AA0*
48 to 60 V DC	3
110 to 125 V DC	4
220 to 250 V DC	5
Command output module 8 relays with 2 NO contacts 48/60 V DC, 110/125 V DC, 220/250 V DC settable	*7TS7200-0AA00-0AA0*
Housing ½ 19-inch for peripheral modules 7SS60 For panel flush mounting or cubicle mounting	*7XP2041-2MA00-0AA0*

Accessories

Description		Order No.
RS232 - RS485 converter		
With power supply unit for 230 V AC		*7XV5700-0AA00*
With power supply unit for 110 V AC		*7XV5700-1AA00*
Converter Full duplex fiber-optic cable – RS485 Auxiliary voltage: 24 V DC to 250 V DC, 110/230 V DC		
Line converter	ST connector	*7XV5650-0BA00*
Cascada converter	ST connector	*7XV5651-0BA00*
Connector for peripheral modules		*W73078-B9005-A710*
Extraction tool for connector		*W73078-Z9005-A710*
Test adapter		*7XV6010-0AA00*
Angle bracket		*C73165-A63-C200-3*

Accessories

Description	Order No.
Summation current matching transformer	
1 A, 50/60 Hz	4AM5120-3DA00-0AN2
5 A, 50/60 Hz	4AM5120-4DA00-0AN2
Matching transformer	
1 A, 50/60 Hz	4AM5120-1DA00-0AN2
5 A, 50/60 Hz	4AM5120-2DA00-0AN2
1 A, 5 A, 50/60 Hz	4AM5272-3AA00-0AN2
Manual 7SS60	
English	E50417-G1176-C132-A2
Design Guide 7SS60	
English	E50417-P1176-C155-A1
DIGSI 4	
Software for configuration and operation of Siemens protection relays running under MS Windows (version Windows 95 and higher) device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00

9

Connection diagrams

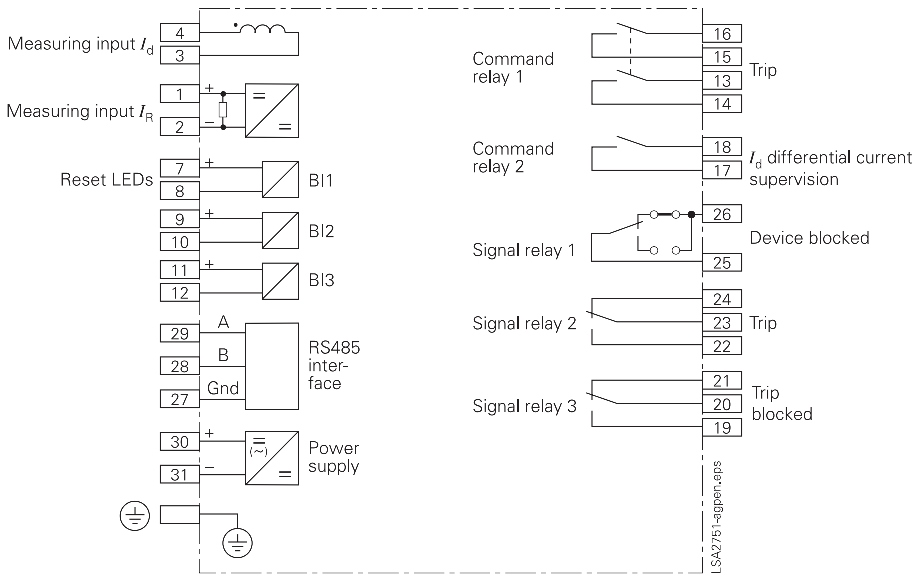


Fig. 9/13 Connection diagram for 7SS601

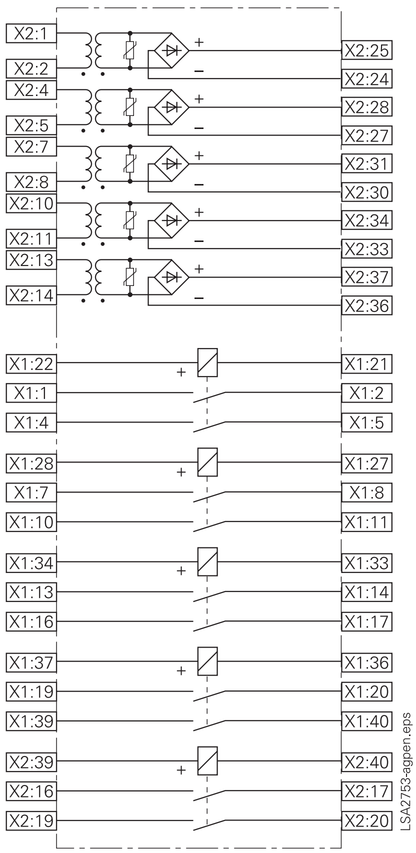


Fig. 9/14 Connection diagram for 7TM700

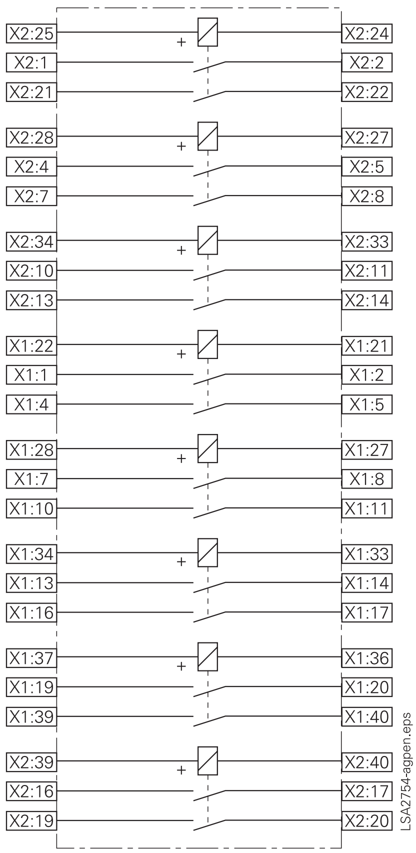


Fig. 9/15 Connection diagram for 7TS720

Connection diagram

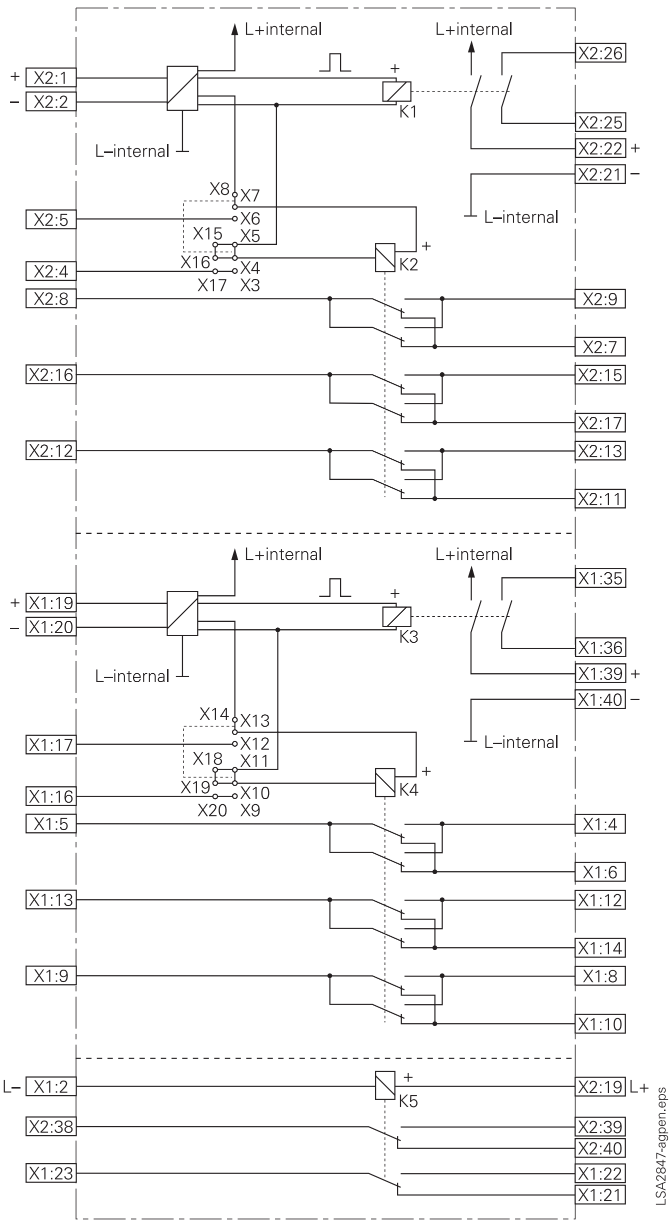


Fig. 9/16 Block diagram of 7TR710

SIPROTEC 4 7SS52 Distributed Numerical Busbar and Breaker Failure Protection

Fig. 9/17 SIPROTEC 4
7SS52 busbar protection system

Description

The SIPROTEC 7SS52 numerical protection is a selective, reliable and fast protection for busbar faults and breaker failure in medium, high and extra-high voltage substations with various possible busbar configurations.

The protection is suitable for all switchgear types with iron-core or linearized current transformers. The short tripping time is especially advantageous for applications with high fault levels or where fast fault clearance is required for power system stability.

The modular hardware allows the protection to be optimally matched to the busbar configuration. The decentralized arrangement allows the cabling costs in the substation to be drastically reduced. The 7SS52 busbar protection caters for single, double or triple busbar systems with or without and quadruple busbar systems without transfer bus with up to: 48 bays, 16 bus couplers, and 24 sectionalizing isolators and 12 busbar sections.

Function overview

Busbar protection functions

- Busbar differential protection
- Selective zone tripping
- Very short tripping time (<15 ms)
- Extreme stability against external fault, short saturation-free time (≥ 2 ms)
- Phase-segregated measuring systems
- Integrated check zone
- 48 bays can be configured
- 12 busbar sections can be protected
- Bay-selective intertripping

Breaker failure protection functions

- Breaker failure protection (single-phase with/without current)
- 5 operation modes, selectable per bay
- Separate parameterization possible for busbar and line faults
- Independently settable delay times for all operation modes
- 2-stage operation bay trip repeat/trip busbar
- Intertrip facility (via teleprotection interface)
- “Low-current” mode using the circuit-breaker auxiliary contacts

Additional protection functions

- End-fault protection with intertrip or bus zone trip
- Backup overcurrent protection per bay unit (definite-time or inverse-time)
- Independent breaker failure protection per bay unit

Features

- Distributed or centralized installation
- Easy expansion capability
- Integrated commissioning aids
- Centralized user-friendly configuration / parameterization with DIGSI
- Universal hardware

Communication interfaces

- FO interface
  – IEC 60870-5-103 protocol
- Electrical interface
  – IEC 61850 protocol
  with EN 100 module (firmware V4.6)

9

Application

The 7SS52 distributed numerical busbar and breaker failure protection system is a selective, reliable and fast protection for busbar faults and breaker failure in medium, high and extra-high voltage substations with various possible busbar configurations. The protection is suitable for all switchgear types with iron-core or linearized current transformers. The short tripping time is especially advantageous for applications with high fault levels or where fast fault clearance is required for power system stability.

The modular hardware design allows the protection system to be optimally matched to the busbar configuration.

The distributed arrangement allows the cabling costs between bay and substation to be drastically reduced. The 7SS52 busbar protection caters for single, double and triple busbar systems with or without transfer bus and quadruple busbar systems without transfer bus with up to:
– 48 bays
– 16 bus couplers
– 24 sectionalizing isolators
– 12 busbar sections

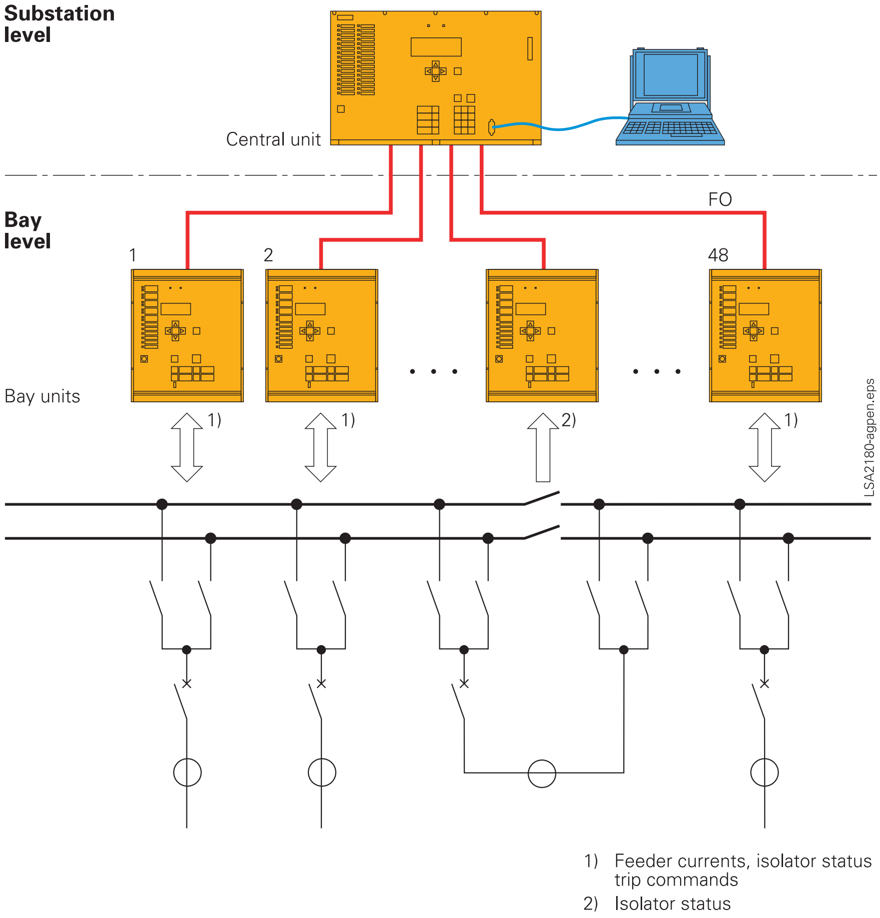


Fig. 9/18 Distributed system structure

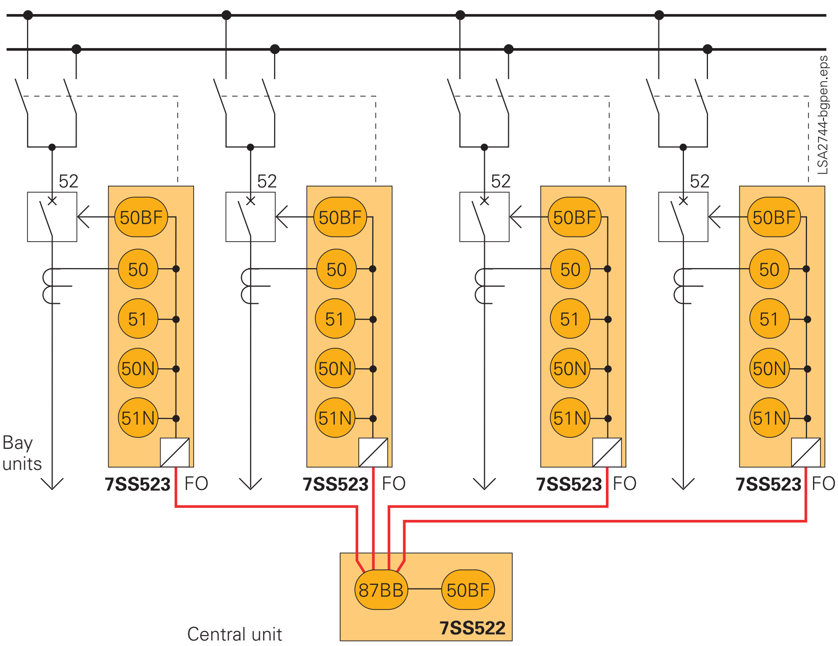


Fig. 9/19 Protection functions of the central unit and the bay units

Construction

The distributed bay units measure the 3 phase currents in each bay. The rated input current is 1 or 5 A and therefore eliminates the need for interposing current transformers. The isolator status, breaker failure protection triggering, bay out-of-service and other bay status information is derived via marshallable binary inputs in the bay units. The complete information exchange is conveyed to the central unit via a fiber-optic interface. The bay unit also has an interface on the front side for connection to a PC for operation and diagnosis. The trip and intertrip commands are issued via trip contacts in the bay units. The 7XP20 standard housing is available in a flush or surface mounting version (7SS523).

The central unit is connected to the bay units via fiber-optic communication links. The connection is built up in a star configuration. The central unit also contains serial ports for system configuration via PC or communication with a substation control system, an integrated LC Display with keypad and marshallable binary inputs, LEDs and alarm relays. The central unit is available in a 19" SIPAC module rack version for either cubicle or wall mounting.

Because of its modular hardware design, it is easy to adapt the central unit to the substation or to expand it with further modules each being connected with up to 8 bay units.

Each bay unit and the central unit has its own internal power supply.

LSP2377-afpen.tif

Fig. 9/20 7SS522 Central unit
Front view of SIPAC subrack version

LSP2515.tif

Fig. 9/21 7SS522 Central unit
Rear view

LSP2076-afp.tif

Fig. 9/22 7SS523 Bay unit
Front view of panel/flush/cubicle mounting unit

LSP2516.tif

Fig. 9/23 7SS525 Bay unit
Front view of panel/flush/cubicle mounting unit

Protection functions

Busbar protection

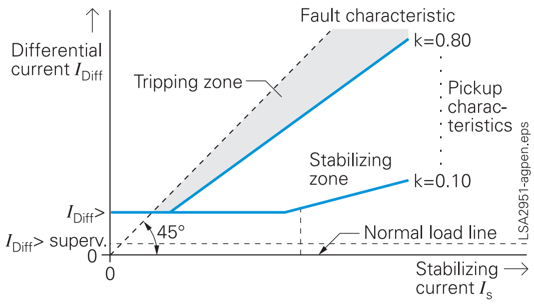
The main function of the 7SS52 is busbar protection, and has the following characteristics:

- Evaluation of differential currents, with stabilization by through-currents based on the proven performance of the Siemens busbar protection 7SS1 and 7SS50/51, currently in service worldwide
- Selective busbar protection for busbars with up to 12 busbar sections and 48 bays
- Integrated "check zone" (evaluation of all busbar section currents without use of the isolator replica)
- Very short tripping time (15 ms typical)
- Selective detection of short-circuits, also for faults on the transfer bus, with transfer trip to the remote end.
- Detection and clearance of faults between the current transformer and the circuit-breaker via current measurement and selective unbalancing.
- Tripping only when all three fault detection modules recognize a busbar fault (2 measurement processors and check zone processor)
- No special CT requirements (stability is guaranteed, even when the CTs saturate after 2 ms)
- Selective output tripping relays per feeder in bay units.

Mode of operation

The 7SS52 protection relay offers complete numerical measured-value processing from sampling to digital conversion of the measured variables through to the circuit-breaker tripping decision. The bay units dispose of sufficient powerful contacts to directly trip the circuit-breaker.

For each busbar section and for all three phases, two independent processors execute the protection algorithm on alternate data samples. Based on the proven performance of the 7SS1 and 7SS50/51, this method of measurement ensures highest stability even in case of high short-circuit currents and CT saturation.



The pickup characteristic can be set independently for selective busbar protection, for the "check zone" and for the breaker failure protection.

Fig. 9/24
Standard characteristic

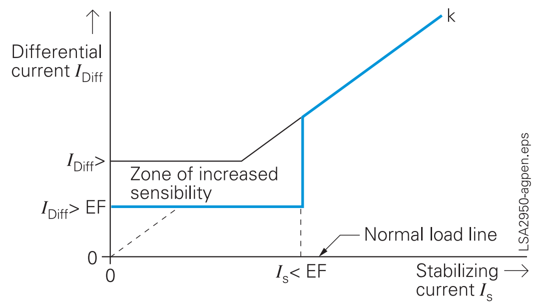


Fig. 9/25
Earth-fault characteristic

In addition, an isolator status independent check-zone measurement is executed on a further processor thus increasing the protection against unwanted operation. All three processors must reach a trip decision independently before the trip command is released.

The isolator status is monitored using normally open and normally closed contacts to enable plausibility checks for both status and transition time. The contact monitoring voltage is also supervised.

In case of an auxiliary voltage failure in the bay, the latest isolator status is stored and a bay-selective indication of the failure is issued.

The assignment of the feeder currents to the corresponding busbar systems is controlled by software via the isolator replica. The isolator replica is applied for both busbar protection and breaker failure protection.

The integrated breaker failure protection function provides phase-segregated two-stage operation (bay-specific trip repeat, trip bus section). Alternatively, an external breaker failure protection relay can issue its trip commands via the isolator replica in the 7SS52.

Breaker failure protection

The 7SS52 protection includes an integrated breaker failure protection with the following features:

- Five breaker failure protection modes that are selectable:

  1. Following the issue of a trip signal from a feeder protection, the busbar protection monitors the drop-off of the trip signal. If the feeder current is not interrupted before a set time delay the polarity of the feeder current is reversed, which results in a differential current in the corresponding section of the bus protection. For this function, a separate parameter set is used.

  2. Following a trip signal from a feeder protection, a trip signal will be output after a settable time delay from the 7SS52 protection to the corresponding feeder circuit-breaker. If this second trip signal is also unsuccessful, the unbalancing procedure according to mode 1) as described above will take place.

  3. With external stand-alone breaker failure protection, the isolator replica of the 7SS52 may be used to selectively trip the busbar section with the faulty circuit-breaker.

Protection functions

4. Following a trip signal from the feeder protection, the 7SS52 monitors the drop-off of the trip signal. If, after a settable time, the current does not fall below a settable limiting value, busbar-selective feeder trip commands are issued with the help of the isolator replica within the 7SS52.

5. Following a trip signal from a feeder protection, a trip signal will be output after a settable time delay from the 7SS52 protection to the corresponding feeder circuit-breaker. If this second trip signal is also unsuccessful, the tripping as described under 4) will take place.

- For single-pole or multi-pole starting, delay times are available.
- Breaker failure detection following a busbar fault by comparison of the measured current with a set value.
- For all modes of breaker failure protection, a transfer trip command output contact is provided for each feeder to initiate remote tripping.

Sensitive earth-fault protection

Within resistive earthed networks, single-phase short-circuit currents are limited to rated current values. In order to provide a busbar protection for these cases, an independent characteristic is available. This characteristic presents separate parameters for the pickup threshold, as well as for a limitation of efficiency. The activation of the characteristic takes place by means of a binary input in the central unit, i.e. by recognizing a displacement voltage.

End-fault protection

The location of the current transformer normally limits the measuring range of the busbar protection. When the circuit-breaker is open, the area located between the current transformer and the circuit-breaker can be optimally protected by means of the end-fault protection. In the event of a fault, depending on the mounting position of the current transformer, instantaneous and selective tripping of the busbar section or intertripping of the circuit-breaker at the opposite end occurs.

Backup protection

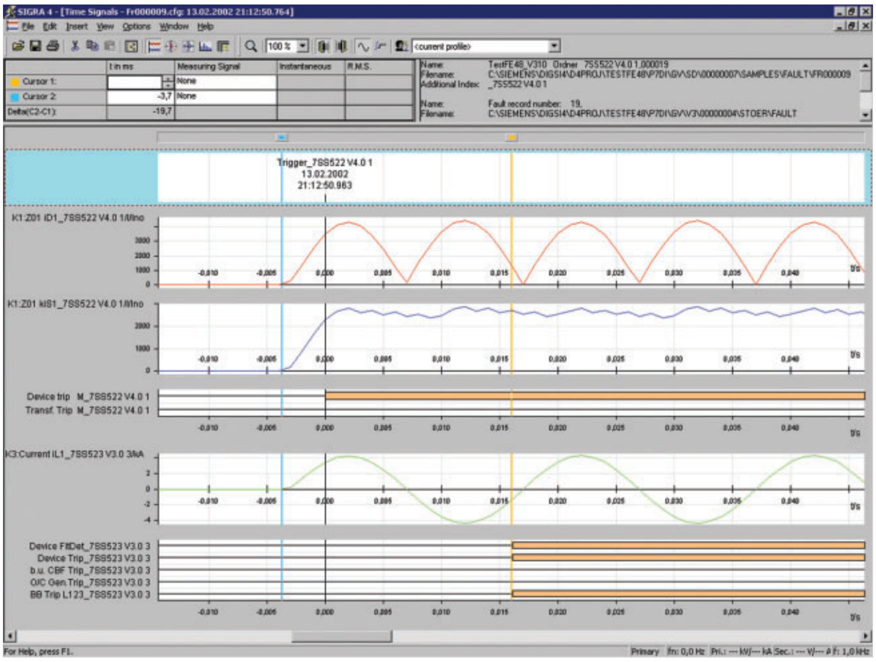
As an option, a two-stage backup protection, independent of the busbar protection is included in every bay unit. This backup protection is completed by means of a breaker failure protection. The parametrization and operation can be carried out in the central unit or locally in each bay unit with the DIGSI operating program.

Isolator replica

The isolator replica is used for both the busbar protection and the breaker failure protection.

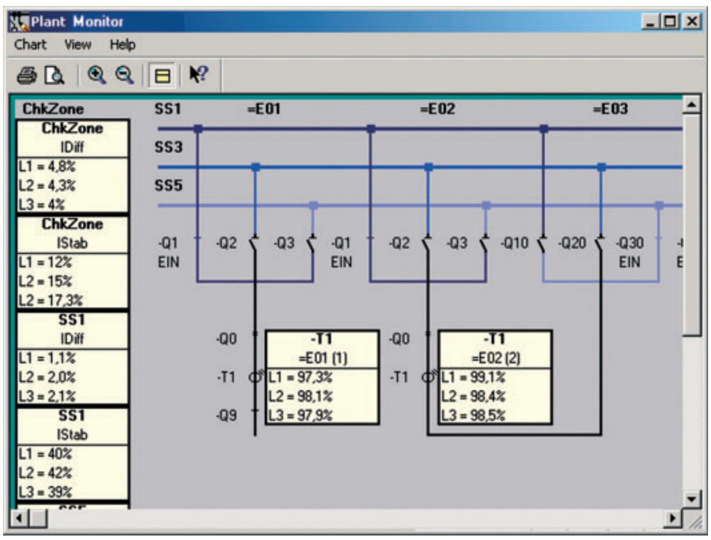
The following features characterize the isolator replica function:

- Includes up to 48 bays and 12 busbar sections
- Integrated bi-stable isolator status characteristic (status stored on loss of auxiliary power).



LSP2388-afpen.tif

Fig. 9/26 Fault record



LSP2389-afpen.tif

Fig. 9/27 DIGSI plant configuration

Protection functions/Functions

- Isolator transition time monitoring.
- By the assignment "NOT open = closed", the isolator is taken to be CLOSED during the transition time.
  Accurate matching of the isolator auxiliary contacts with the main contact is not required.
- Menu-guided graphic configuration with DIGSI operating program.
- LEDs in the bay modules indicate the actual status of the busbar isolators.
- Dynamic visualization of the substation with DIGSI on the central unit.

Tripping command/reset

The tripping output processing for the 7SS52 protection has the following features:

- Bay-selective tripping by bay units
- Settings provided for overcurrent release of the tripping command (to enable selective tripping of infeeding circuits only)
- Settable minimum time for the trip command.
- Current-dependent reset of the tripping command.

Disturbance recording

The digitized measured values from the phase currents and the differential and stabilizing currents of the busbar sections and check zone are stored following a trip decision by the 7SS52 or following an external initiation via a binary input. Pre-trigger and post-fault times with regard of the trip command can be set. Up to 8 fault recordings are stored in the 7SS52. The fault records may be input to a PC connected to the central unit, using the menu-guided DIGSI operating program. Then, the SIGRA graphics program makes it possible to easily analyze the fault recordings.

Marshallable tripping relays, binary inputs, alarm relays and LEDs

The bay units are equipped with marshallable command relays for direct circuit-breaker tripping. For each bay there are 9 (7SS523) or 8 (7SS525) duty contacts available.

For user-specific output and indication of events, 16 alarm relays and 32 LEDs in the central unit are freely marshallable.

Several individual alarms may be grouped together.

The central unit has marshallable binary inputs with:

- Reset of LED display
- Time synchronization
- Blocking of protection functions

The bay units have marshallable binary inputs:

- Isolator status closed/open
- Phase-segregated start of circuit-breaker failure protection
- Release of circuit-breaker failure protection
- Release of TRIP command
- Circuit-breaker auxiliary contacts
- Bay out of service
- Test of circuit-breaker tripping

Measurement and monitoring functions

In the 7SS52 protection relay, a variety of measurement and monitoring functions is provided for commissioning and maintenance. These functions include:

- Measurement and display of the phase currents of the feeders in the central unit and bay units.
- Measurement and display (on the integrated LCD or PC) of the differential and stabilizing currents of all measuring systems in the central unit and the bay units.
- Monitoring of busbar-selective and phase-segregated differential currents with busbar-selective blocking/alarming
- Monitoring of the differential currents of the check zone with alarming/blocking
- Phase-segregated trip test including control of feeder circuit-breaker (by central or bay unit)
- Removal of a bay from the busbar measurement processing during feeder service and maintenance via central or bay units (bay out of service)
- Blocking of breaker failure protection or tripping command for testing purposes.
- Isolator replica freezing (maintenance) with alarm indication ("Isolator switching prohibition").
- Cyclic tests of measured-value acquisition and processing and trip circuit tests including coils of the command relays.

Event recording

The 7SS52 protection provides complete data for analysis of protection performance following a trip or any other abnormal condition and for monitoring the state of the relay during normal service.

Up to 200 operational events and 80 fault annunciations with a resolution of one millisecond may be stored in two independent buffers:

- Operational indications
  This group includes plant/substation operation events, for example isolator switching, isolator status discrepancies (transition time limit exceeded, loss of auxiliary voltage, etc.) or event/alarm indications
- Tripping following a busbar short-circuit fault or circuit-breaker failure.

Protection functions/Functions

Settings

A PC can be connected to the operator interface located at the front panel or the rear of the central unit. An operating program is available for convenient and clear setting, fault recording and evaluation as well as for commissioning. All settings of the busbar or breaker failure protection, as well as settings of additional functions such as backup protection, need only be parameterized at the central unit. Settings at the bay units are not necessary.
With the help of the integrated keypad and display on the central unit, all setting parameters may be read out.
Keypad, display (7SS523) and the front side interface of the bay units serve for commissioning, display of operational values and diagnosis.
All parameters are written into nonvolatile memories to ensure that they are retained even during loss of auxiliary voltage.

Configuration, visualization

The configuration of the 7SS52 is effected by means of a graphics-orientated editor included in the DIGSI operation program. For frequently used bay types, a symbol library is available. Enhancements can be easily effected anytime.
A graphical configuration visualizes the states of the isolator position, the circuit-breaker and measuring values.

Self-monitoring

Hardware and software are continuously monitored and any irregularity is immediately detected and alarmed. The self-monitoring feature improves both the reliability and the availability of the 7SS52. The following quantities are monitored:

- The current transformer circuits
- The analog-to-digital conversion
- All internal supply voltages
- The program memory
- The program running times by a watch dog function
- The isolator status
- The three channel tripping circuit

Maximum lifetime and reliability

The hardware of the 7SS52 units is guaranteed by 20 years of experience in numerical protection design at Siemens. The number of components employed is reduced through use of a powerful microprocessor in conjunction with highly-integrated components, thus enhancing the reliability. The experience gained by Siemens in production of over 140,000 numerical protection units has been incorporated in the software design. The most modern manufacturing methods together with effective quality control ensure high reliability and a long service life.

Battery monitoring

The internal battery is used to back-up the clock and memory for storage of switching statistics, status and fault indications and fault recording, in the event of a power supply failure. The processor checks its capacity at regular intervals. If the capacity of the battery is found to be declining, an alarm is generated. Routine replacement is therefore not necessary. All setting parameters are stored in the Flash-EPROM, and therefore not lost if the power supply or the battery fails.

Functions for testing and commissioning

The 7SS52 offers auxiliary functions for commissioning. The physical status of all binary inputs and output relays of the central unit can be displayed and directly altered to facilitate testing.

All measured values can be clearly depicted by means of DIGSI and simultaneously displayed in different windows as primary or percentage values.

The 7SS52 units are provided with a circuit-breaker test function. Single-pole and three-pole TRIP commands can be issued.

Data transmission lockout

Data transmission lockout can be activated, so as to prevent transfer of information to the control center during work on a circuit bay.

Test mode

During commissioning, a test mode can be selected; all indications then have a test mode suffix for transmission to the control system.

Communication

Serial communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- Already during the process of communication, information is assigned to the cause thereof (e.g. assignment of the indication "circuit-breaker TRIP" to the corresponding command).
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.

Local and remote communication

The 7SS52 central unit provides several serial communication interfaces for various tasks:

- Front interface for connecting a PC
- Rear-side service interface (always provided) for connection to a PC, either directly or via a modern
- System interface for connecting to a control system via IEC 60870-5-103 protocol.
- System interface (EN 100 module) for connecting to a control system via IEC 61850 protocol
- Time synchronization via IRIG-B/DCF/system interface

Serial front interface (central unit and bay units)

There is a serial RS232 interface on the front of all the units. All of the unit's functions can be set on a PC by means of the DIGSI 4 protection operation program. Commissioning tools and fault analysis are also built into the program and are available through this interface.

Communication (continued)

Rear-mounted interfaces (central unit only)

A number of communication modules suitable for various applications can be fitted in the rear of the flush-mounting housing. The interface modules support the following applications:

- Service interface
  The service interface was conceived for remote access to a number of protection units via DIGSI. It can be an electrical RS232/RS85 or an optical interface.
- RS485 bus
  With this data transmission via copper conductors, electromagnetic fault influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problem.

System interface

Communication with a central control system takes place through this interface. Radial or ring type station bus topologies can be configured depending on the chosen interface. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.

IEC 61850 protocol (retrofittable)

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between protection units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103 protocol

The IEC 60870-5-103 protocol is an international standard for the transmission of protective data and fault recordings. All messages from the unit and also control commands can be transferred by means of published, Siemens-specific extensions to the protocol.

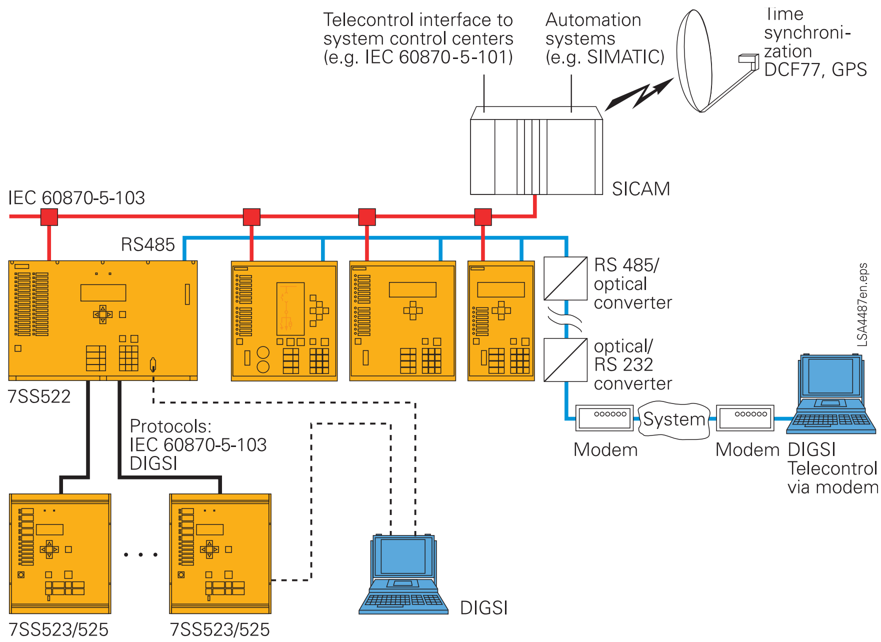


Fig. 9/28 Communication structure with DIGSI and IEC 60870-5-103

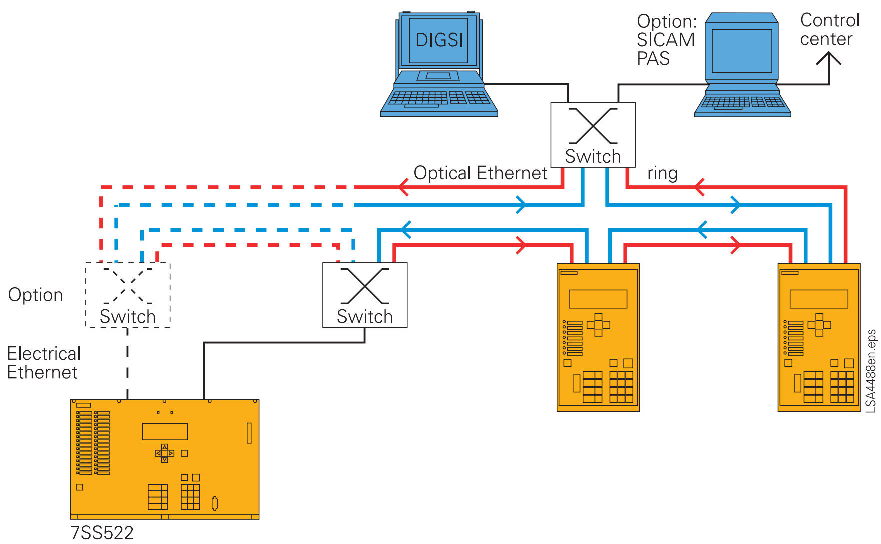


Fig. 9/29 Communication structure for station bus with Ethernet and IEC 61850, FO ring

Time synchronization

The battery-backed clock of the 7SS52 central unit can be synchronized via:

- DCF 77 signal via time synchronization receiver
- IRIG-B satellite signal via time synchronization receiver
- Minute-pulse via binary input
- System interface by the substation control, e.g. SICAM

Date and time with milliseconds resolution is assigned to every indication. The synchronization of the 7SS52 bay units is automatically effected with the central unit.

Technical data

General unit data

Input circuits			
Rated current I_N		1 or 5 A	
Rated frequency f_N		50/60 Hz	
Thermal overload capability in current path	Continuous 10 s 1 s	4 x I_N 10 x I_N 100 x I_N	
Dynamic overload capability		250 x I_N	
Burden of current inputs	At I_N = 1 A At I_N = 5 A	< 0.1 VA < 0.2 VA	
Auxiliary voltage			
Rated auxiliary voltage V_{aux}	Central unit	48/60, 110/125, 220/250 V DC	
Rated auxiliary voltage V_{aux}	Bay unit	48, 60 to 250 V DC	
Permissible tolerance V_{aux}		–20 to +20 %	
Maximum ripple		≤ 15 %	
Power consumption		Configuration dependent	
Central unit	Quiescent Energized	70 to 120 W 75 to to 130 W	
Bay unit		7SS523	7SS525
	Quiescent Energized		10 W 14 W
Max. bridging time during loss of voltage supply		> 50 ms at V_{aux} ≥ 60 V	
Binary inputs			
		7SS523	7SS525
Number of binary inputs	Bay unit Central unit	20 12	10
Voltage range		24 to 250 V DC	
Current consumption		Approx. 1.5 mA/input	
Alarm/event contacts			
Central unit			
Number of relays	Marshallable Fixed	16 (each 1 NO contact) 1 (2 NC contacts)	
Switching capacity	Make/Break	20 W/VA	
Switching voltage		250 V AC/DC	
Permissible current		1 A	
Bay unit		7SS523	7SS525
Number of relays	Marshallable Fixed	1 (1 NO contact) 1 (2 NC contacts)	1 (1 NO contact) 1 (1 NC contacts)
Switching capacity	Make/Break	20 W/VA	
Switching voltage		250 V AC/DC	
Permissible current		1 A	
Command contacts			
Number of relays (bay unit)		7SS523	7SS525
		4 (each 2 NO contacts) 1 (1 NO contact)	3 (each 2 NO contacts) 2 (1 NO contact)
Switching capacity	Make Break	1000 W/VA 30 W/VA	
Switching voltage		250 V AC/DC	
Permissible current	Continuous 0.5 s	5 A 30 A	

LEDs

Central unit		
Operation indication	Green	1
Device failure	Red	1
Marshallable	Red	32
Bay unit		
Operation indication	Green	1
Device failure	Red	1
Indications	Green Red	5 (7SS523)/– (7SS525) 11 (7SS523)/1 (7SS525)

Control, displays

Central unit	
LC Display	4 lines x 20 characters
Membrane keyboard	24 keys
Bay unit (7SS523)	
LC Display	4 lines x 16 characters
Membrane keyboard	12 keys

Serial interfaces

Central unit	
PC interface (front)	
Connection, electrical	SUB-D, 9-pin (subminiature ISO 2110)
Baud rate	1200 to 115000 baud
System interface IEC 60870-5-103 (rear)	
Connection, optical electrical	ST connectors SUB-D, 9-pin (subminiature ISO 2110)
Baud rate	1200 to 115000 baud
System interface IEC 61850 (rear)	
Connection, electrical with EN 100 module	RJ45 connector
Baud rate	up to 100 Mbaud
Service interface (rear)	
Connection, optical electrical	ST connectors SUB-D, 9-pin (subminiature ISO 2110)
Baud rate	1200 to 115000 baud
Bay unit	
PC interface (front)	
Connection, electrical	SUB-D, 9-pin (subminiature ISO 2110)
Baud rate	1200 to 19200 baud
Central/bay unit	
Interface for high-speed data communication	
Connection	ST connectors
Fiber-optic cable	Glass fiber 62.5/125 µm
Optical wavelength	820 nm
Permissible cable attenuation	Max. 8 dB
Transmission distance	Max. 1.5 km

Technical data

Unit design (degree of protection according to EN 60529)		
Central unit		
Cubicle	IP 54	
Housing for wall mounting	IP 55	
SIPAC subrack	IP 20	
Bay unit	7SS523	7SS525
Housing	IP 51	IP 20
Terminals	IP 21	
Weight at max. configuration		
Central unit		
SIPAC subrack	14.3 kg	
Surface-mounting housing	43.0 kg	
Bay unit	7SS523	7SS525
Flush mounting	8.1 kg	5.5 kg
Surface mounting	11.8 kg	

Electrical tests	
Specification	
Standards	IEC 60255-5, DIN 57435 part 303
High-voltage test (routine test), except DC voltage supply input	2 kV (r.m.s.), 50 Hz
High-voltage test (routine test), only DC voltage supply input	2.8 kV DC
Impulse voltage test (type test), all circuits, class III	5 kV (peak), 1.2/50 µs, 0.5 J, 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for interference immunity; *type test*	
Standards	IEC 60255-6, IEC 60255-22 (international product standard), EN 50082-2 (European generic standard for industrial environment), VDE 0435 part 303 (German product standard)
High-frequency test with 1 MHz interference IEC 60255-2-1, class III and VDE 0435 part 303, class III	2.5 kV (peak), 1 MHz, τ = 15 µs, 400 surges/s, duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV and IEC 61000-4-2, class IV	8 kV contact discharge, 15 kV air discharge, both polarities, 150 pF, R_I = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3, class III	10 V/m, 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated IEC 61000-4-3, class III	10 V/m, 80 to 1000 MHz, AM 80 %, 1 kHz
Irradiation with radio-frequency field, pulse-modulated ENV 50204, class III	10 V/m, 900 MHz, repetition rate 200 Hz, duty cycle 50 %
Fast transients interference/bursts IEC 60255-22-4, class IV; IEC 61000-4-4, class IV; IEC 60801-4	4 kV, 5/50 ns, 5 kHz, burst length = 15 ms, repetition rate 300 ms, both polarities, R_I = 50 Ω, duration 1 min
Line-conducted disturbances induced by radio-frequency fields, amplitude-modulated IEC 61000-4-6, class III	10 V, 150 kHz to 80 MHz, AM 80 %, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous, 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz

1) I_{NO} = highest c.t. ratio.

EMC tests for interference emission; *type test*	
Standard	EN 50081-2 (European generic standard for industrial environment)
Conducted interference voltage, auxiliary voltage CISPR 11, EN 55011 and VDE 0875 part 11	150 kHz to 30 MHz, limit class B
Radio interference field strength CISPR 11, EN 55011 and VDE 0875 part 11	30 to 1000 MHz, limit class B

Mechanical stress tests	
Specification	
Standards	IEC 60255-21-1, IEC 6068-2
Permissible mechanical stress	
During service	10 to 60 Hz, 0.035 mm amplitude 60 to 500 Hz, 0.5 *g* acceleration
During transport	5 to 8 Hz, 7.5 mm amplitude 8 to 500 Hz, 2 *g* acceleration

Climatic stress tests	
Temperatures	
Standard	IEC 60255-6
Permissible ambient temperature	
– In service	–10 °C to +55 °C (bay unit) – 5 °C to +55 °C (central unit)
– For storage	–25 °C to +70 °C
– During transport	–25 °C to +70 °C
– During start-up	–10 °C to +55 °C (bay unit) 0 °C to +55 °C (central unit)
Humidity	
Standards	IEC 60068-2-3
It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation not permissible!
Busbar configuration	
Quadruple or triple busbar with transfer busbar;	
Number of bays	48
Number of bus sections	12
Number of bus couplers	16
Number of sectionalizers	24
Number of coupler bus sections	12
Busbar protection	
Tripping characteristics	
Setting ranges	
Overcurrent I/I_{NO} 1)	0.2 to 4 (in steps of 0.01)
Stabilizing factor k for busbar-selective protection	0.1 to 0.8 (in steps of 0.01)
Stabilizing factor k for check zone	0 to 0.8 (in steps of 0.01)
Tripping time	
Typical trip time	15 ms
Differential current monitoring	
Setting ranges	
Current limit I/I_{NO} 1)	0.05 to 0.8 (in steps of 0.01)
Time delay	1 to 10 s (in steps of 1 s)

9

Technical data

Breaker failure protection

Tripping	
Setting ranges	
Overcurrent I/I_N	0.05 to 2 (in steps of 0.01)
Stabilizing factor k	0 to 0.8 (in steps of 0.01)
Time delay for unbalancing / $I >$ query	0.05 to 10 s (in steps of 0.01 s)
Time delay for TRIP repeat	0.00 to 10 s (in steps of 0.01 s)

Modes of operation
- Individually selectable per feeder:
  - $I >$ query
  - TRIP repeat (1/3-phase) with $I >$ query
  - Unbalancing (1-stage BF)
  - Unbalancing with TRIP repeat (1/3-phase, 2-stage BF)
  - TRIP by external BF protection (tripping via isolator replica of busbar protection)
  - Plus for each mode (except for TRIP by external BF): low-current mode
  - Plus for modes with TRIP repeat: pulse mode

Breaker failure protection for busbar short-circuit	
Setting value	
Overcurrent I/I_N	0.05 to 2 (in steps of 0.01)
Time delay	0.05 to 10.00 s (in steps of 0.01 s)

General data of the protection system

Min. time of TRIP commands	
Setting range	0.02 to 1 s (in steps of 0.01 s)
Current threshold for command reset I/I_N	0.05 to 2 (in steps of 0.10)
Overcurrent release of TRIP commands	
Setting range	0 to 25 (in steps of 0.01)
Isolator transition time	
Setting range	1 to 180 s (in steps of 0.01 s)

Overcurrent protection in the bay unit

Characteristics	Definite-time or inverse-time overcurrent protection
Setting ranges	
High-set stage; $I >>$ (phase) I/I_N	0.05 to 25.00 (in steps of 0.01)
High-set stage; $I_E >>$(earth) I/I_N	0.05 to 25.00 (in steps of 0.01)
Trip time delays; $T_I >>$, $T_{IE} >>$	0.00 to 60.00 s or ∞
Definite-time overcurrent protection	
Overcurrent stage; $I >$ (phase) I/I_N	0.05 to 25.00 (in steps of 0.01)
Overcurrent stage; $I_E >$ (earth) I/I_N	0.05 to 25.00 (in steps of 0.01)
Trip time delays; $T_I >$, $T_{IE} >$	0.00 to 60.00 s or ∞
Inverse-time overcurrent protection	
Inverse time O/C stage; I_p (phase) I/I_N	0.10 to 4.00 (in steps of 0.01)
Inverse time O/C stage; I_E (earth) I/I_N	0.10 to 4.00 (in steps of 0.01)
Trip time delays; T_{Ip}, T_{IE}	0.00 to 10.00 s or ∞
Characteristics	Inverse (IEC 60255-3 type A) Very inverse (IEC 60255-3 type B) Extremely inverse (IEC 60255-3 type C)

1) I_{NO} = highest c. t. ratio.

Additional functions

Self-diagnosis

Current monitoring per feeder
Auxiliary voltage monitoring
Cyclic test
Check of the data transmission between central unit and bay units
Memory tests

Operational measured values: Central unit

Feeder currents	I_{L1}; I_{L2}; I_{L3} in A primary and in % I_N
Range	0 to 1000 % I_N
Tolerance	typically 2 % of measured value
Differential and restraint (stabilizing) currents of all bus sections (separate for ZPS-BSZ1 and ZPS-BSZ2)	I_{dL1}; I_{dL2}; I_{dL3} I_{sL1}; I_{sL2}; I_{sL3} in % I_N
Range	0 to 1000 % I_N

Operational measured values: Bay unit

Feeder currents	I_{L1}; I_{L2}; I_{L3}; I_E in A primary and in % I_N
Range	0 to 6 000 % I_N
Tolerance	typically 2 % of measured value
Differential and restraint (stabilizing) currents	I_{dL1}; I_{dL2}; I_{dL3} I_{sL1}; I_{sL2}; I_{sL3}
Range	0 to 6 000 % I_N
Frequency	f in Hz ($I > 0.1\ I_N$)
Range	$f_N \pm 5$ Hz
Tolerance	0.1 Hz

Event recording: Central unit

Storage of the last 200 operational events and 80 fault events

Event recording: Bay unit

Storage of the last 50 operational events and 100 fault events

Fault recording: Central unit

Resolution	1 ms at 50 Hz; 0.83 ms at 60 Hz
Storage time (from busbar TRIP or external initiation by binary input)	– 500 to + 500 ms at 50 Hz – 416 to + 416 ms at 60 Hz (up to 8 fault records)

Fault recording: Bay unit

Resolution	1 ms at 50 Hz; 0.83 ms at 60 Hz
Storage time (from busbar TRIP or external initiation by binary input)	– 500 to + 500 ms at 50 Hz – 416 to + 416 ms at 60 Hz (up to 8 fault records)

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonisation of the laws the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).
This unit conforms to the international standard IEC 60255 and the German standard DIN 57435/Part 303 (corresponding to VDE 0435 part 303).
The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.
This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

9

Selection and ordering data

Description	Order No.	Order-code
7SS522 distributed busbar/breaker failure protection	7SS52□0-□□□□□-1□A0	□□□
Central unit		
Central unit 50/60 Hz	2	
Rated auxiliary voltage		
48, 60 V DC	3	
110, 125 V DC	4	
220, 250 V DC	5	
Unit design		
In subrack ES902C	A	
In wall-mounting housing	B	
In 8MF cubicle	F	
Regional presettings/regional functions and languages		
Region DE, language German (language can be selected)	A	
Region World, language English (UK) (language can be selected)	B	
Region US, language English (US) (language can be selected)	C	
Region FR, language French (language can be selected)	D	
Region World, language Spanish (language can be selected)	E	
Region World, language Italian (language can be selected)	F	
Region World, language Russian (language can be selected)	G	
System interface		
Without	0	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
Service interface (on rear of relay)		
DIGSI 4/modem, electrical RS232	1	
DIGSI 4/modem, electrical RS485	2	
DIGSI 4/modem, optical 820 nm, ST connector	3	
Equipped for		
8 bays	A	
16 bays	B	
24 bays	C	
32 bays	D	
40 bays	E	
48 bays	F	

Description	Order No.
7SS523 distributed busbar/breaker failure protection	7SS52□□-□□A01-□AA1
Bay unit, frequency, housing, binary inputs and outputs	
Bay unit, 50/60 Hz, housing 1/2 x 19", 20 BI, 6 BO, 2 live status contacts	3
Rated current	
1 A	1
5 A	5
Rated auxiliary voltage	
48 V DC	2
60 to 250 V DC	5
Unit design	
7XP2040-2 for flush mounting or cubicle mounting	C
7XP2040-1 for surface mounting	D
7XP2040-2 for flush mounting without glass cover	E
Additional functions	
Without additional functions	0
With overcurrent-time protection	1

Selection and ordering data

Description	Order No.
7SS525 distributed busbar/breaker failure protection *Bay unit, frequency 50/60 Hz;* *Housing 1/3 x 19"; 10 BI, 6 BO, 1 live status contact*	*7SS525□-□□A01-□AA1*
Rated current at 50/60 Hz	
1 A	1
5 A	5
Rated auxiliary voltage at converter	
48 to 250 V DC	5
Unit design	
7XP2040-2 for panel flush mounting or cubicle mounting without glass cover	F
Additional functions	
Without additional functions	0
With overcurrent-time protection	1

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection relays running under MS Windows (version Windows 2000/XP Professional Edition) device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
Professional + IEC 61850 DIGSI 4 Basis and additionally SIGRA (fault record analysis), CDC Editor (logic editor), Display Editor (editor for default and control displays), and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	7XS5403-0AA00
IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	7XS5460-0AA00
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM (contained in DIGSI 4, but can be ordered additionally)	7XS5410-0AA00
Connection cable Cable between PC/notebook (9-pin connector) and protection relay (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
Manual 7SS52 V4.6 English	C53000-G1176-C182-1

Connection diagram

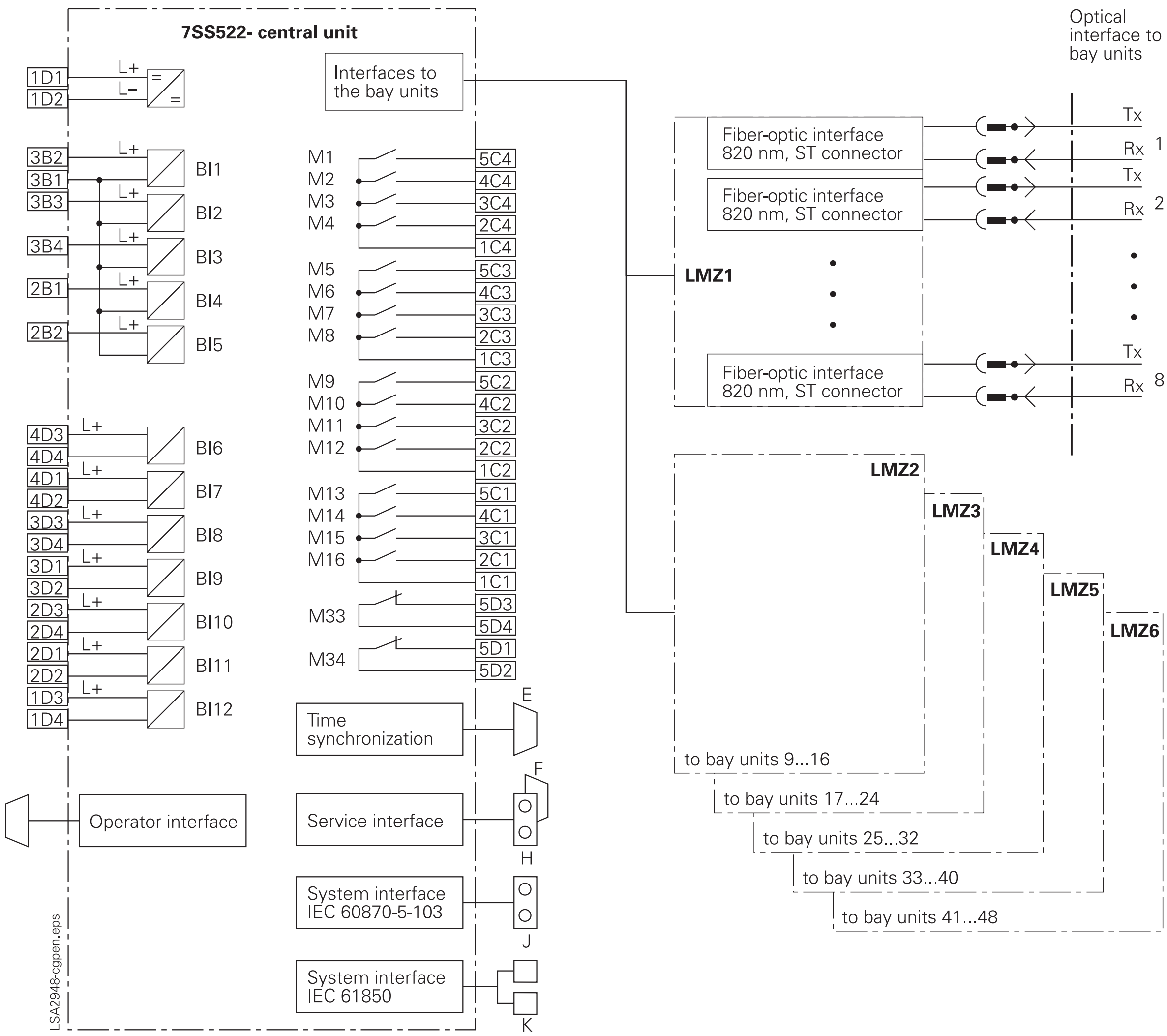


Fig. 9/30 Connection diagram 7SS522

Connection diagram

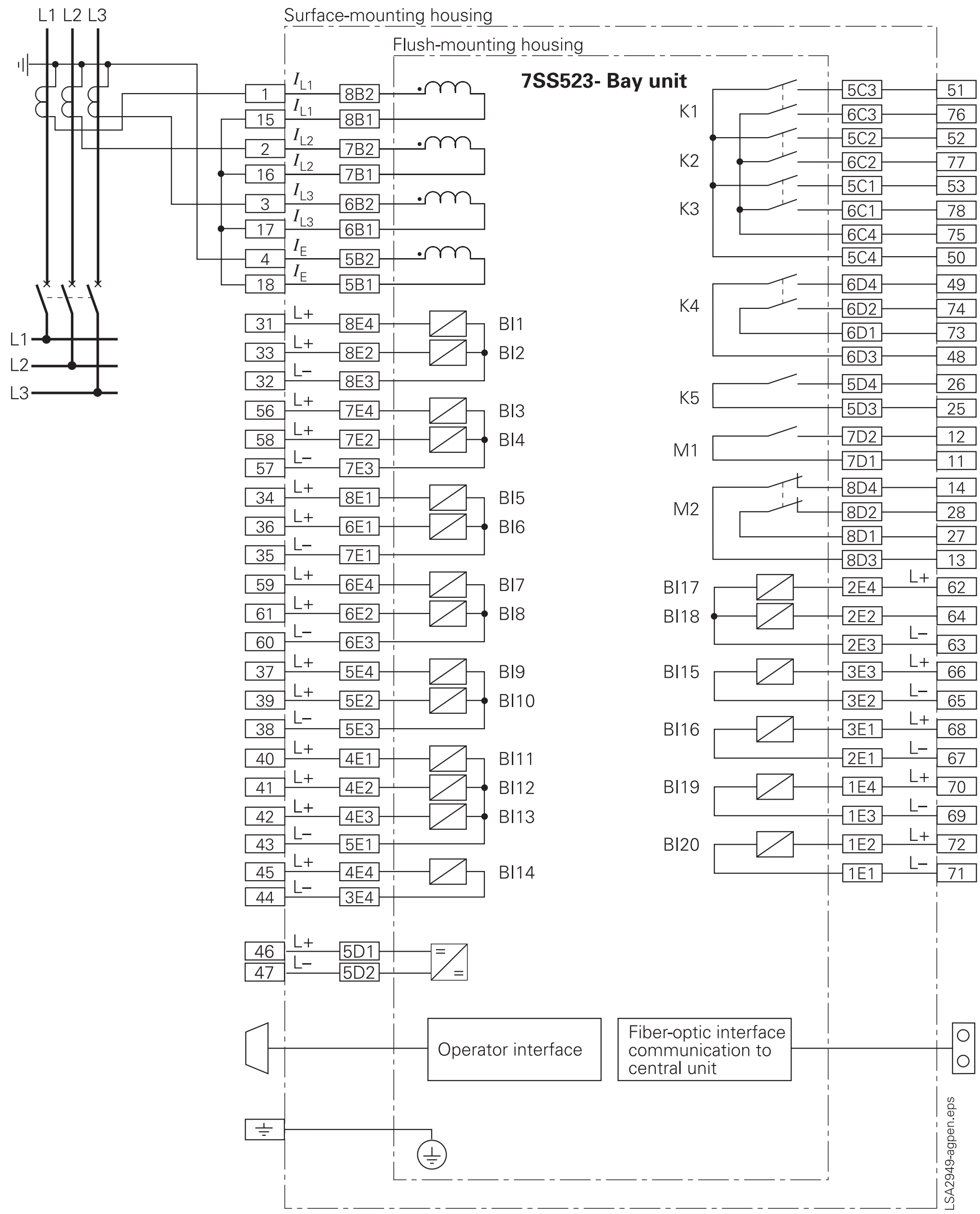


Fig. 9/31 Connection diagram 7SS523

Connection diagram

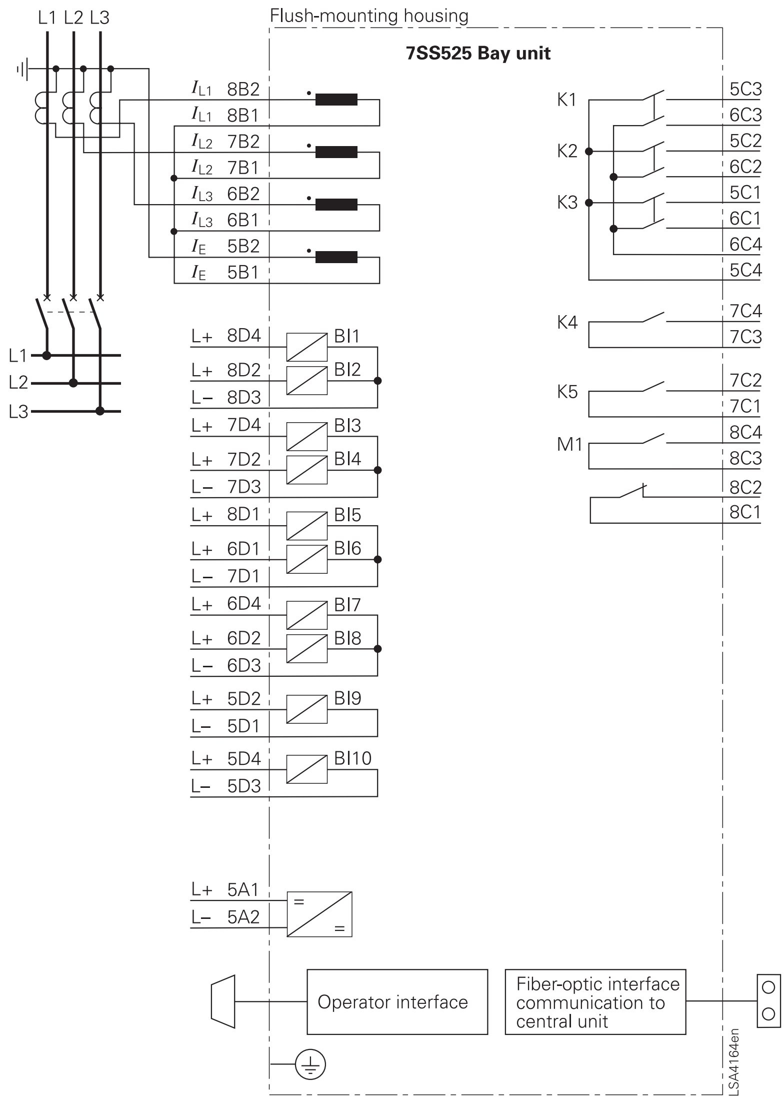


Fig. 9/32 Connection diagram 7SS525

SIPROTEC 7VH60
High-Impedance Differential Protection Relay

Fig. 9/33 SIPROTEC 7VH60 high-impedance protection relay

Function overview

- Robust static design
- Auxiliary DC supply monitor
- Fast operating time (15 ms)
- Simple pickup voltage setting by resistors through shorting links
- LED alarm indicator
- Option “Bus-wire alarm” (supervision)
- Option “Blocked external” by binary input
- Wide-range auxiliary power supply
- Latched trip contact (lockout function). Reset by binary input.
- Adjustable max. voltage pickup setting by a jumper between 60 V or 240 V

Description

The SIPROTEC 7VH60 relay is designed for fast and selective differential protection based on the high-impedance circulating current principle. It is used for the protection of machine stator windings, busbars and transformer and reactor windings against phase-to-phase and phase-to-earth short-circuits.

As an option, the relay includes a bus-wire supervision and the differential function can be blocked by a binary input.

9

Application

The relatively simple electronic design of the 7VH60 provides a robust and reliable relay suitable for all high-impedance circulating-current protection applications.

The use of a static measuring circuit ensures constant and fast tripping times.

Optionally, the relay is available with a bus-wire supervision feature. If during operation a differential current above the supervision pickup threshold but below the relay pickup voltage is detected, the differential protection is blocked after a selectable span of time. The bus-wire supervision pickup threshold is settable by means of jumpers. Likewise, the delay time for pickup of the supervision can be set by jumpers within a range between 1 s and 10 s.

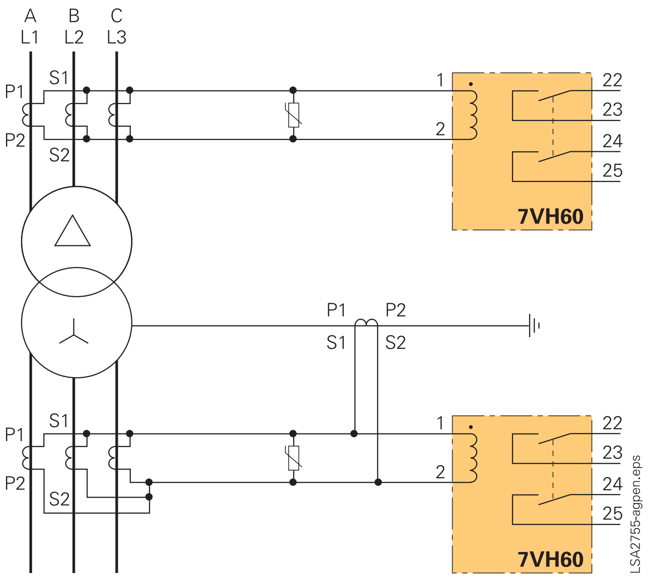


Fig. 9/34 Restricted earth-fault protection of power transformer windings

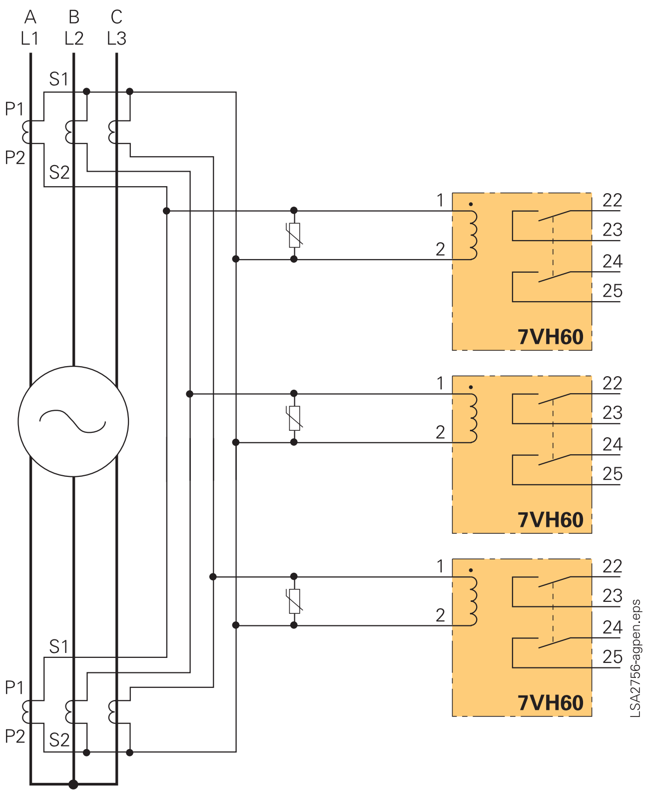


Fig. 9/35 Differential protection of a generator or busbar

Construction

The SIPROTEC 7VH60 high-impedance differential relay contains all the components needed for:

- Acquisition and evaluation of measured values
- Operation and LED display
- Output of trip commands and signals
- Input and evaluation of binary signals
- Auxiliary voltage supply.

All protection functions including the DC/DC converter are accommodated on a printed circuit board of double-height Eurocard format.

An earthing screw is provided at the housing to which earthing strips can be connected in order to ensure low-impedance earthing.

The heavy-duty current plug connector provides automatic shorting of the CT circuits whenever the module is withdrawn.

There are two unit versions available.

The flush-mounting and cubicle-mounting versions have their terminals accessible from the rear.

The surface-mounting version has the terminals accessible from the front.

LSP2382-afp.tif

Fig. 9/36

Protection functions

The 7VH60 relay is a single-pole sensitive current relay. The AC input impedance of the relay is adjusted by means of a series of high-wattage resistors. The relay setting in voltage pickup value is effected by removing shorting links from the rear terminals. When a shorting link is screwed between the terminals, the resistor is shorted out and when the shorting link is removed, the resistor is in circuit.

Each resistor has a voltage value which is the pickup current of 20 mA multiplied by the resistors ohmic value. The relay voltage setting is determined by adding up the voltage drops at the resistors which are not shorted out by shorting links (series resistors in circuit) plus a minimum base voltage setting. A maximum setting of 60 V (shorting links of the left side) or 240 V (shorting links on the right side) is possible. On delivery, the shorting links are pre-installed in either right-side or left-side position, depending on the ordered version.

The input from the CT varistor is connected to terminals 1 and 2. The sensitive relay input transformer galvanically isolates the relay static measuring circuit from the main current transformers.

The AC measured current is filtered and rectified to a proportional DC voltage. This voltage is monitored by a Schmidt trigger circuit. If the set DC voltage, equivalent to the relay rated operating current of 20 mA is exceeded, then the trigger operates to energize the trip contact as well as the operation LED.

The auxiliary DC supply is connected to terminals 30 and 31. An auxiliary DC supply monitoring circuit consisting of a green LED and an NO/NC relay contact is provided to indicate the status of the DC supply.

Technical data

General unit data	
Measuring circuits	
Pickup current	20 mA
Max. settings 24 V version 6 V version	 240 V 1) 60 V
Rated frequency f_N	50/60 Hz
Thermal rating of current input 10 s For 1 s	 2 x setting (volts) 5 x setting (volts)
Tripping threshold (in steps of 6 V)	Max. 60 V 1)
Hysteresis is 0.875 - 0.975 times the tripping voltage	
Tripping threshold (in steps of 24 V)	Max. 240 V
Tripping time 2 x setting 3 x setting 5 x setting	 < 30 ms < 20 ms < 13 ms
Reset time	20 ms
Bus-wire supervision circuit (option)	
Pickup threshold settable by jumpers (in steps of 10 %)	10 - 70 % of tripping threshold Factory setting 20 %
Time delay settable by jumpers (in steps of 1 s)	1 - 10 seconds Factory setting 5 s

1) With a jumper, the max. setting range can be changed from 60 to 240 V.

9

Technical data

Auxiliary voltage	
Auxiliary voltage supply via integrated wide-range power supply	
Rated auxiliary DC voltage V_{aux}	24 to 250 V DC
Permissible voltage ranges	19.2 to 300 V DC
Superimposed AC voltage, peak-to-peak	< 12 % of the power supply voltage
Power consumption Quiescent Energized	 4 W 5 W
Bridging time in the event of power failure/short-circuit of the auxiliary supply voltage	> 50 ms at V > 110 V > 10 ms at V > 24 V DC
Rated auxiliary AC voltage V_{aux}, 50/60 Hz	115 V AC, 230 V AC
Permissible voltage ranges (AC)	88 to 133 V, 176 to 265 V
Command relay (trip)	
Number of relays	1
Number of contacts	2 NO
Switching capacity Make Break	 1000 W/VA 30 W/VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 s
Alarm relays	
2 alarm relays	1 for service 1 for supervision (option)
Contacts per relay	1 NC (service) 1 NO (supervision - option)
Switching capacity Make Break	 1000 W/VA 30 W/VA
Switching voltage	250 V
Permissible current	5 A
Binary inputs	
Number	1 for external reset 1 for external block
Rated voltage range	24 to 250 V DC, bipolar
Current consumption, energized	Approx. 1.8 mA (independent of the control voltage)
Operating points For rated voltages 24/48/60 V DC For rated voltages 110/125/220/250 V DC	Settable by jumpers V_{pickup} > 17 V DC $V_{drop-off}$ < 8 V DC V_{pickup} > 74 V DC $V_{drop-off}$ < 45 V DC
Maximum permissible voltage	300 V DC
LEDs	
LED	Green Service
LED	Red Blocked
LED 1	Red Trip stored
LED 2	Red Bus-wire alarm (supervision)
LED 3	Red Trip blocked (external)
LED 4	Red Trip not stared (Test)

Electrical tests	
Specification	
Standards	IEC 60255-5
Insulation tests	
High-voltage test (100 % test) all circuits except for power supply and binary inputs	2.5 kV (r.m.s.), 50/60 Hz
High-voltage test (100 % test) only power supply and binary inputs	3.5 kV DC
Impulse voltage test (type test) all circuits, class III	5 kV (peak value); 1.2/50 µs ; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for interference immunity; *type test*	
Standards	IEC 60255-6 and 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 Part 303 EN 50263 (product standard)
High-frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak); 1 MHz; τ = 15 µs; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge, both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated IEC 60255-22-3 (report) class III	10 V/m; 27 MHz to 500 MHz
Irradiation with radio-frequency field, non-modulated IEC 61000-4-3, class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz
Irradiation with radio-frequency field, pulse-modulated IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle of 50 %
Fast transient interference/burst IEC 60255-22-4 and IEC 6100-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (Surge), IEC 61000-4-5; class III Power supply	 Common mode: 2 kV; 12 Ω; 9 µF Diff. mode: 1 kV; 2 Ω; 18 µF
Measuring inputs, binary inputs and relay outputs	Common mode: 2 kV; 42 Ω; 0.5 µF Diff. mode: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated; IEC 6100-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power frequency magnetic field; IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz

Selection and ordering data

Description	Order No.
7VH60 high-impedance differential protection relay	*7VH600□-□□A□0-□AA0*
Varistor pickup voltage	
Without varistor	*0*
With varistor up to 125 V_{rms}, 600 A/1S/S256	*1*
With varistor 125 V_{rms} to 240 V_{rms}, 600 A/1S/S1088	*2*
With integrated converter	
24 V to 250 V DC / 80 V to 264 V AC	*0*
Unit design	
For panel surface mounting with terminals at the side (7XP20 housing)	*B*
For panel flush mounting or cubicle mounting with terminals at the back (7XP20 housing)	*E*
Factory setting for pickup voltage	
60 V[1)]	*1*
240 V[1)]	*2*
Additional functions	
Settable command lockout	*0*
Settable command lockout, bus-wire supervision	*1*

Accessories

External shorting link	*C73334-A1-C34-1*
Varistor up to 125 V_{rms}; 600 A/1S/S256	*W73028-V3125-A1*
Varistor 125 V_{rms} to 240 V_{rms}; 600 A/1S/S1088	*W73028-V3300-A2*

9

1) (Can be modified by shorting links and jumper X51).

Connection diagram

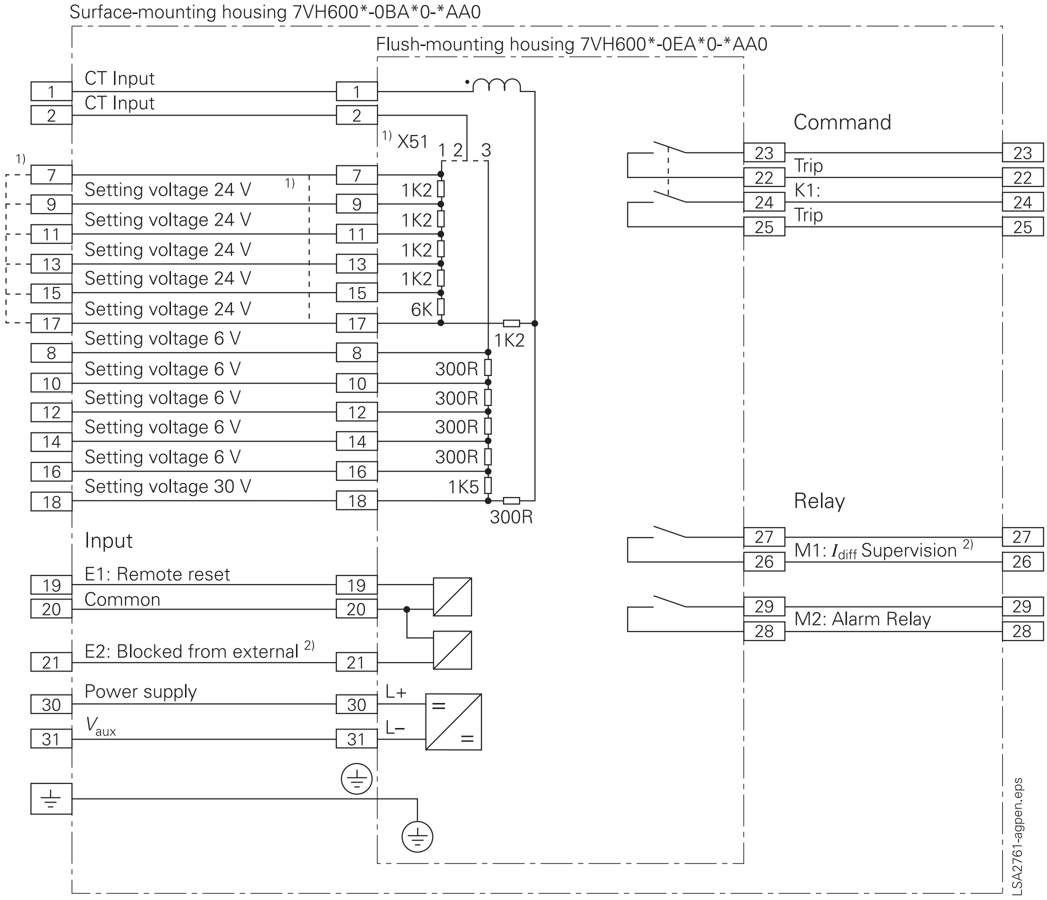


Fig. 9/37 Connection diagram

1) Delivery condition of connectors for 24 V.

2) Input and contacts only available with bus-wire supervision (ordering option).

Relays for Various Protection Applications

Page

SIPROTEC 4 7VK61 Breaker Management Relay

LSP2458-afp.tif

25 50BF
79
59
27
86 74TC

Fig. 10/1
SIPROTEC 4 7VK61 breaker management relay

Description

The SIPROTEC 4 breaker management relay 7VK61 is a highly flexible auto-reclosure, synchro-check and circuit-breaker failure protection unit.

This unit is used for the single and three-pole auto-reclosure of a circuit-breaker, after this circuit-breaker has tripped due to a fault. The synchro-check function ensures that the two circuits being reconnected by closing the circuit-breaker are within a defined safe operating state before the CLOSE command is issued.
The 7VK61 is also applicable as circuit-breaker failure protection. A breaker failure occurs when the circuit-breaker fails to correctly open and clear the fault after single or three-pole trip commands have been issued by the protection. It is then necessary to trip the relevant busbar zone (section) to ensure fault clearance. Together with the above-mentioned protection functions, the following additional functions of the 7VK61 can be applied: end-fault protection, pole-discrepancy protection, overvoltage protection and undervoltage protection. As a member of the numerical SIPROTEC 4 relay family, it also provides control and monitoring functions and therefore supports the user with regard to a cost-effective power system management.

Function overview

Protection functions

- Single and/or three-pole auto-reclosure
- Synchro-check with live/dead line/bus measurement
- Closing under asynchronous conditions (consideration of CB operating time)
- Circuit-breaker failure protection with two stages (single and three-pole with/without current)
- End-fault protection
- Pole-discrepancy protection
- Overvoltage/undervoltage protection

Control function

- Commands f. ctrl. of CB and isolators

Monitoring functions

- Operational measured values
- Self-supervision of the relay
- Event buffer and fault protocols
- Oscillographic fault recording
- Monitoring of CB auxiliary contacts
- Switching statistics

Features

- All functions can be used separately
- Initiation/start by phase-segregated or 3-pole trip commands
- Auto-reclosure for max. 8 reclose cycles
- Evolving/sequential trip recognition
- Auto-reclosure with ADT, DLC, RDT
- Synchro-check with ΔV, $\Delta\varphi$, Δf measurement
- Breaker failure protection with highly secure 2-out-of-4 current check detectors
- Breaker failure protection with short reset time and negligible overshoot time

Communication interfaces

- Front interface for connecting a PC
- System interface for connecting to a control system via various protocols
  – IEC 60870-5-103 protocol
  – PROFIBUS-FMS/-DP
  – DNP 3.0
- Rear-side service/modem interface
- Time synchronization via
  – IRIG-B or DCF77 or system interface

10

Application

The 7VK61 provides highly flexible breaker management. It applies to single-breaker, ring-bus, and 1½ breaker installations. The auto-reclosure, synchronism-check, breaker failure protection and voltage protection functions can be used separately or combined. Therefore the current and voltage transformer connection can be selected according to the required application.

The auto-reclosure function closes the circuit-breaker after this circuit-breaker has tripped due to a fault. The check-synchronism function ensures that the two circuits being reconnected by closing the circuit-breaker are within a defined safe operating state before the CLOSE command is issued.

The numerical 7VK61 relay provides rapid backup fault clearance in case the circuit-breaker nearest to the fault fails to respond to a TRIP command. It is suitable for power systems of all voltage levels with single and/or three-pole circuit-breaker operation. The initiation signal can be issued from any protection or supervision equipment. Information from the circuit-breaker auxiliary contact is only required for the breaker failure protection during faults which produce little or no fault current flow, for instance due to a trip from the power transformer Buchholz protection.

Cost-effective power system management

The SIPROTEC 4 units are numerical relays which also provide control and monitoring functions and therefore support the user with regard to a cost-effective power system management. The security and reliability of the power supply is increased as a result of minimizing the use of hardware.

The local operation has been designed according to ergonomic criteria. Large, easy-to-read backlit displays are provided.

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a benchmark-level of performance in protection and control.

If the requirements for protection, control and interlocking change, it is possible in the majority of cases to implement such changes by means of parameterization using DIGSI 4 without having to change the hardware.
The use of powerful microcontrollers and the application of digital measured-value conditioning and processing largely suppresses the influence of higher-frequency transients, harmonics and DC components.

ANSI	
50BF	Breaker-failure protection
59/27	Overvoltage/undervoltage protection
25	Synchro-check
79	Auto-reclosure
74TC	Trip circuit supervision
86	Lockout (CLOSE command interlocking)

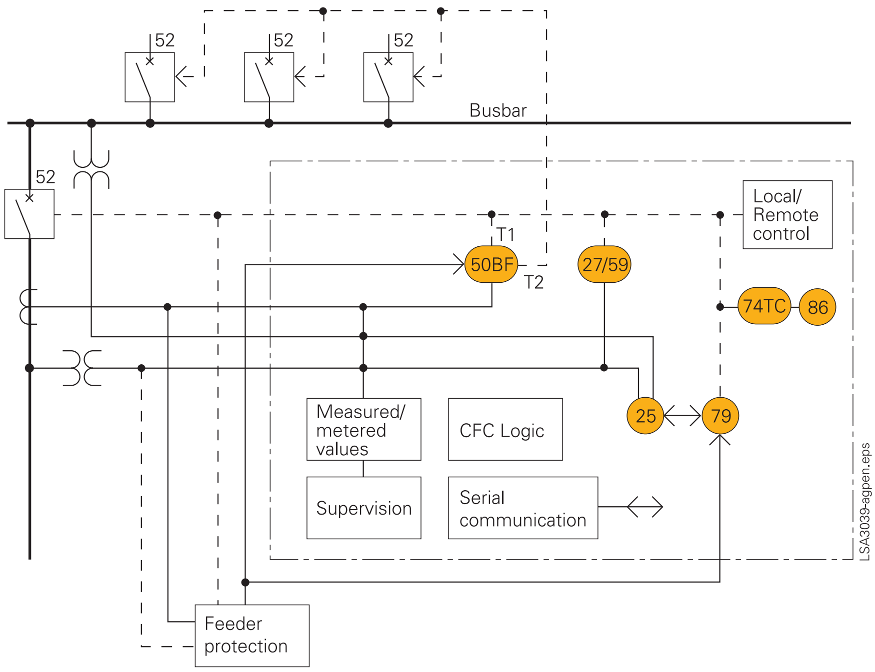


Fig. 10/2 Application and function diagram

10

Construction

Connection technique and housing with many advantages

1/3 and 1/2-rack sizes are available as housing widths of the SIPROTEC 4 7VK61 relays, referred to a 19" modular frame system. This means that previous models can always be replaced. The height is a uniform 255 mm for flush-mounting housings and 266 mm for surface-mounting housings for all housing widths. All cables can be connected with or without ring lugs.

In the case of surface mounting on a panel, the connection terminals are located above and below the housing in the form of screw-type terminals. The communication interfaces are located in a sloped case at the top and bottom of the housing.

Fig. 10/3
Flush-mounting housing with screw-type terminals

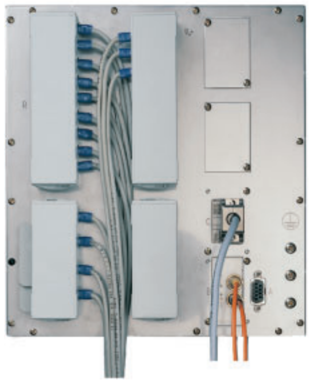


Fig. 10/4
Rear view of flush-mounting housing with covered connection terminals and wirings

Fig. 10/5
Surface-mounting housing with screw-type terminals, example 7SA63

Fig. 10/6
Communication interfaces in a sloped case in a surface-mounting housing

10

Protection functions

Auto-reclosure (ANSI 79)

The 7VK61 relay is equipped with an auto-reclose function (AR). Usually the auto-reclosure interacts with the feeder protection via binary inputs and outputs.

The function includes several operating modes:

- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosing for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with the internal or an external synchro-check
- Monitoring of the circuit-breaker auxiliary contacts.

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC).

The 7VK61 allows the line-side voltages to be evaluated. A number of voltage-dependent supplementary functions are thus available:

- ADT
  The adaptive dead time is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- DLC
  By means of dead-line check, reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure in case that the synchronism check can not be used).
- RDT
  Reduced dead time is employed in conjunction with auto-reclosure where no teleprotection method is employed: when faults within the zone extension of a distance feeder protection but external to the protected line, are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped, that the fault has been cleared by the protection on the faulted downstream feeder and that reclosure with reduced dead time may take place.

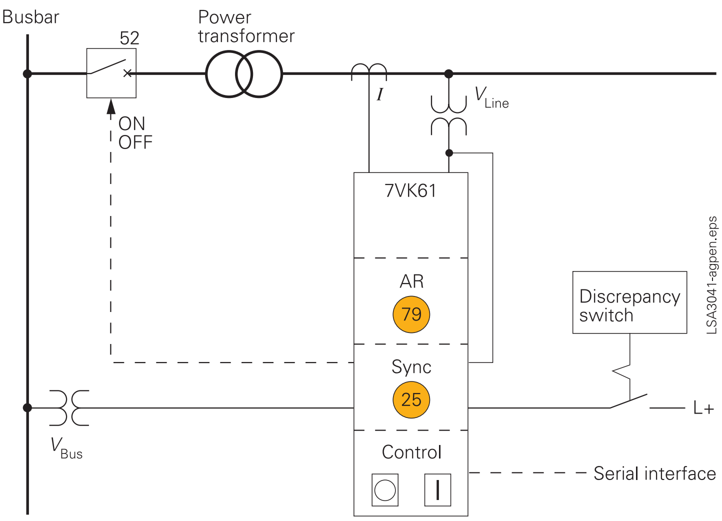


Fig. 10/7 Auto-reclosure and synchro-check with voltage measurement across a power transformer

Synchronism check (ANSI 25)

Where two network sections are switched in by control command or following a 3-pole auto-reclosure, it must be ensured that both network sections are mutually synchronous. For this purpose, a synchronism-check function is provided. After verification of the network synchronism, the function releases the CLOSE command. Consideration of the duration of the CB operating time before issuing the CLOSE command (especially important under asynchronous conditions and when several circuit-breakers with different operating times are to be operated by one single relay).

In addition, reclosing can be enabled for different criteria, e.g., when the busbar or line are not carrying a voltage (dead line or dead bus).

Breaker failure protection (ANSI 50BF)

The 7VK61 relay incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example due to a defective circuit-breaker. The current detection logic is phase-segregated and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or the busbar trip command will be generated. The breaker failure protection will usually be initiated by external feeder protection relays via binary input signals. Trip signals from the internal auto-reclosure logic or from the voltage protection can start the breaker failure protection as well.

Overvoltage protection, undervoltage protection (ANSI 59, 27)

The 7VK61 contains a number of overvoltage measuring elements. Each measuring element is of two-stage design. The following measuring elements are available:

- Phase-to-earth overvoltage
- Phase-to-phase overvoltage
- Zero-sequence overvoltage
  The zero-sequence voltage can be connected to the 4th voltage input (not in conjunction with syncho-check) or be derived from the phase voltages.
- Negative-sequence overvoltage

Tripping by the overvoltage measuring elements can be effected either at the local circuit-breaker or at the remote station by means of a transmitted signal.

The 7VK61 is fitted, in addition, with three two-stage undervoltage measuring elements:

- Phase-to-earth undervoltage
- Phase-to-phase undervoltage
- Positive-sequence undervoltage

The undervoltage measuring elements can be blocked by means of a minimum current criterion and by means of binary inputs.

10

Protection functions

End-fault protection

When the circuit-breaker is open, the area located between the current transformer and the circuit-breaker can be optimally protected by means of the end-fault protection. In the event of a fault, an independently settable time delay is started after a valid initiation has been received and the circuit-breaker auxiliary contacts indicate an open circuit-breaker position, with current still flowing (see Fig. 10/8). Depending on the mounting position of the current transformer, instantaneous tripping of the busbar section or intertripping of the circuit-breaker at the opposite end occurs.

Pole-discrepancy protection

This function ensures that any one or two poles of a circuit-breaker do not remain open for longer than an independently settable time (i.e. unsymmetrical conditions). This time stage is initiated when current (above the set value) is flowing in any 1 or 2 phases, but not in all 3 phases. Additionally, the circuit-breaker auxiliary contacts (if connected) are interrogated and must show the same condition as the current measurement. Should this time delay expire, then a three-pole trip command is issued. This function is normally used when single-pole auto-reclosing is applied.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs for each circuit-breaker pole can be used for monitoring the circuit-breaker trip coils including the connecting cables. An alarm signal is issued whenever the circuit is interrupted. The trip circuit supervision function requires one or two independent potential-free binary inputs per trip circuit. To make existing (non potential-free) binary inputs potential-free, external optocoupler modules can be applied.

Lockout (ANSI 86)

Under certain operating conditions, it is advisable to block CLOSE commands after a final TRIP command of the relay has been issued. Only a manual 'Reset' command unblocks the CLOSE command. The 7VK61 is equipped with such an interlocking logic.

Monitoring functions

The 7VK61 relay provides comprehensive monitoring functions covering both hardware and software. Furthermore, the measured values are continuously checked for plausibility. Therefore the current and voltage transformers are also included in this monitoring system.
If all voltages are connected, the relay will detect secondary voltage interruptions by means of the integrated fuse failure monitor. Immediate alarm and blocking of the synchronism check and dead line check is provided for all types of secondary voltage failures. Additional measurement supervision functions are

- Symmetry of voltages and currents (in case of appropriate transformer connection)
- Broken-conductor supervision (if current transformers are connected)
- Summation of currents and voltages (in case of appropriate transformer connection)
- Phase-sequence supervision (if three voltage transformers are connected)

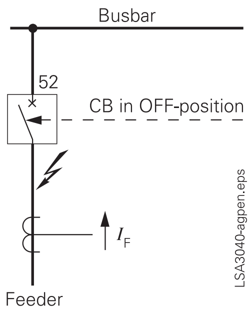


Fig. 10/8
End-fault between circuit-breaker and current transformer

Communication

With respect to communication, particular emphasis is placed on the customer requirements in energy automation:

- Every data item is time-stamped at the source, i.e. where it originates.
- The communication system automatically handles the transfer of large data blocks (e.g. fault recordings or parameter data files). The user has access to these features without any additional programming effort.
- For the safe execution of a control command the corresponding data telegram is initially acknowledged by the device which will execute the command. After the release and execution of the command a feedback signal is generated. At every stage of the control command execution particular conditions are checked. If these are not satisfied, command execution may be terminated in a controlled manner.

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program is particularly advantageous during commissioning.

Service/modem interface

By means of the RS 485/RS 232 interface, it is possible to efficiently operate a number of protection units centrally via DIGSI 4. Remote operation is possible by using a modem. This offers the advantage of rapid fault clarification, especially in the case of unmanned substations. With the optical version, centralized operation can be implemented by means of a star coupler.

Reliable bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic interference influences are largely eliminated by the use of twisted-pair conductors. Upon failure of a unit, the remaining system continues to operate without any problems.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance. It is usually impossible to communicate with a unit that has failed. Should the unit fail, there is no effect on the communication with the rest of the system.

Retrofitting: Modules for every type of communication

Communication modules for retrofitting are available for the entire SIPROTEC 4 family. These ensure that, where different communcation protocols (IEC 60870-5-103, PROFIBUS, DNP, etc.) are required, such demands can be met. For fiber-optic communication, no external converter is required for SIPROTEC 4.

IEC 60870-5-103 protocol

IEC 60870-5-103 is an internationally standardized protocol for efficient communication with protection relays.
IEC 60870-5-103 is supported by a number of protection relay manufacturers and is used world-wide. Supplements for the control function are defined in the manufacturer-specific part of this standard.

PROFIBUS-FMS

PROFIBUS-FMS is an internationally standardized system (EN 50170) for communication. PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world. Connection to a SIMATIC programmable controller is made on the basis of the data obtained (e.g. fault recording, fault data, measured values and control functionality) via the SICAM energy automation system.

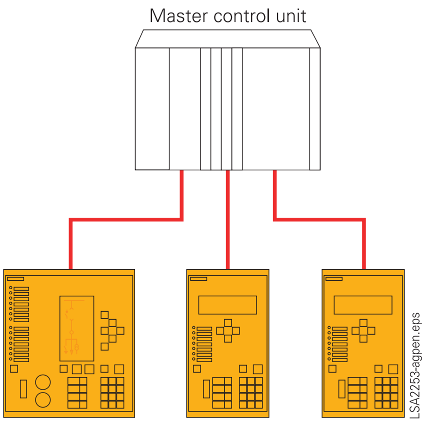


Fig. 10/9
IEC 60870-5-103 star type RS232 copper conductor connection or fiber-optic connection

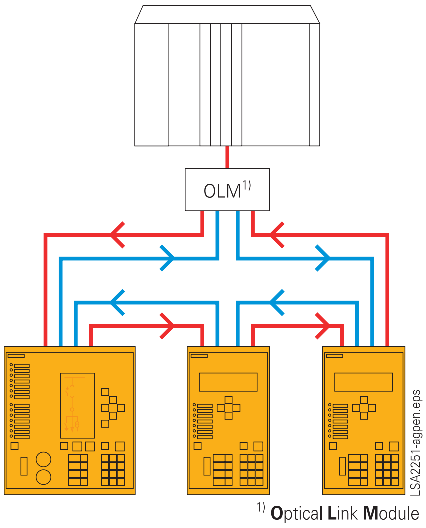


Fig. 10/10
Bus structure: Fiber-optic double ring circuit

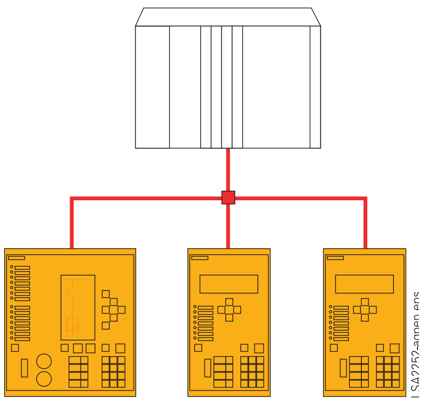


Fig. 10/11
Bus structure: RS485 copper conductor connection

Communication

PROFIBUS-DP

PROFIBUS-DP is an industrial communication standard and is supported by a number of PLC and protection relay manufacturers.

DNP 3.0

DNP 3.0 (Distributed Network Protocol, Version 3) is an internationally recognized protection and bay unit communication protocol. SIPROTEC 4 units are Level 1 and Level 2 compatible.

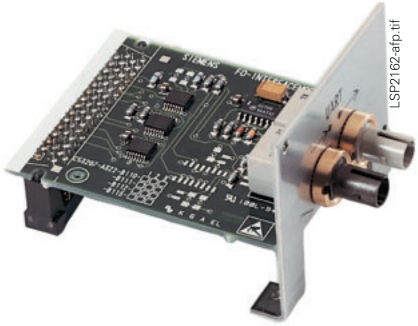


Fig. 10/12
Fiber-optic communication module

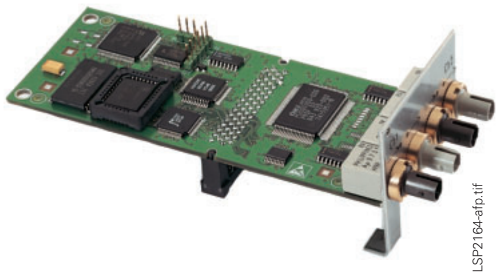


Fig. 10/13
Fiber-optic double ring communication module

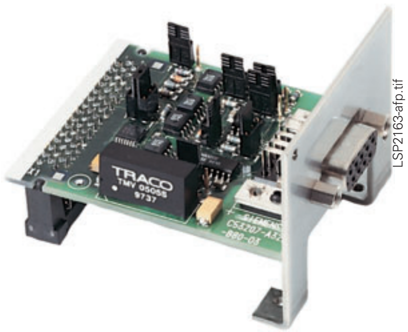


Fig. 10/14
Electrical communication module

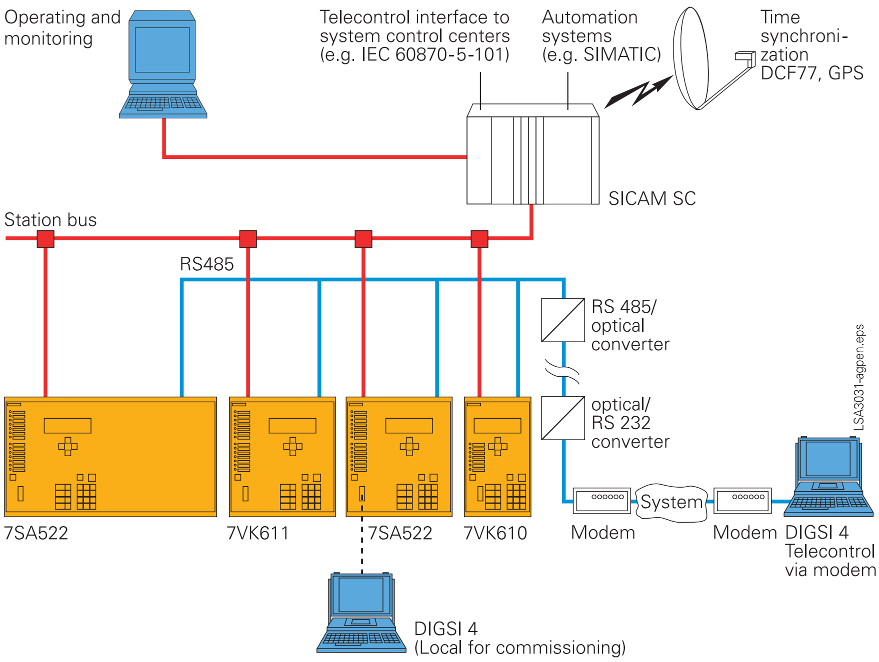


Fig. 10/15
Communication

10

Typical connection

Connection for current and voltage transformers

With the transformer connection as shown in Fig. 10/16, it is possible to use the complete scope of functions of 7VK61, i.e. breaker failure protection, synchronism check with 3-phase dead line check (with or without auto-reclosure), complete measured value monitoring, voltage protection, and the complete range of operational measured values.

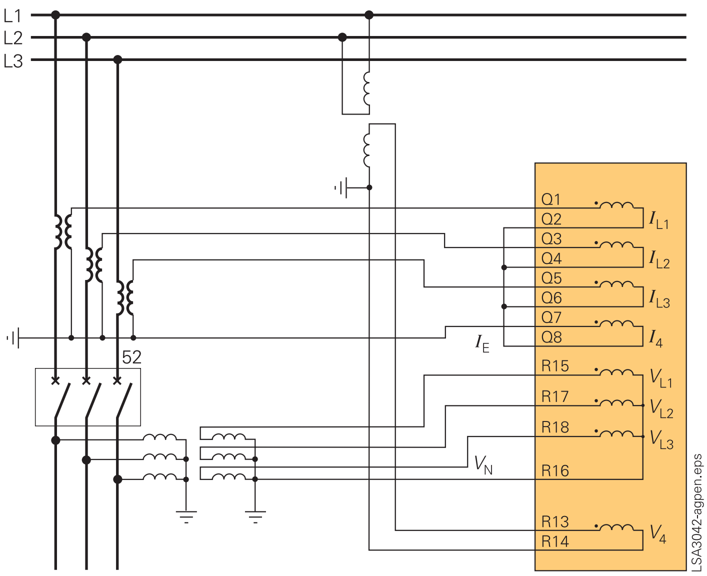


Fig. 10/16
Complete connection of all current and voltage transformers

Alternative: Connection for current transformers only

The connection for current transformers only provides breaker failure protection and current operational measured values.

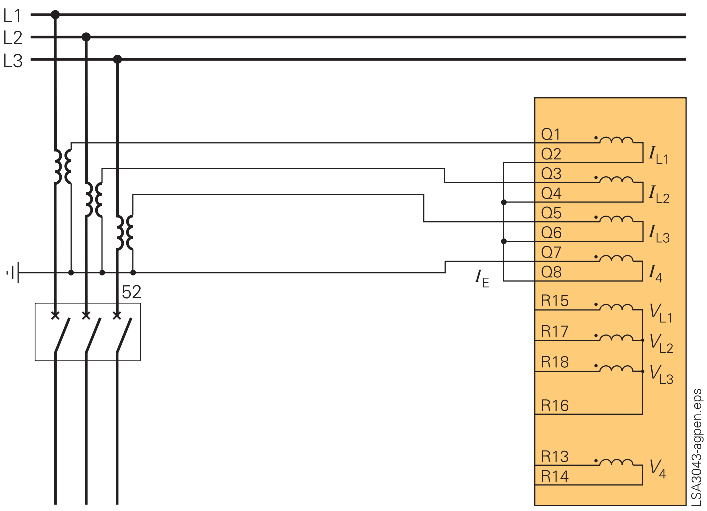


Fig. 10/17
Typical current transformer connection for breaker failure protection

Typical connection

Alternative: Connection for two voltage transformers

In case of a connection for two voltage transformers, synchro-check and two operational measured voltages, and additionally synchro-check measured values are applicable. Dead line check is performed for the connected line voltage only.

Note: Please connect the two voltages always to the terminals R15/R16 and R13/R14 with the appropriate polarity. The setting address 106 “Voltage transformer” must then be set to “single-phase”. The terminals R17 and R18 must not be connected.

The connection of the voltage V_{L1-L2} as shown in Fig. 10/18 is just an example: any other of the shown combinations is possible for synchronization.

The two voltage transformer connection can also be combined with the current transformer connection according to Fig. 10/17.

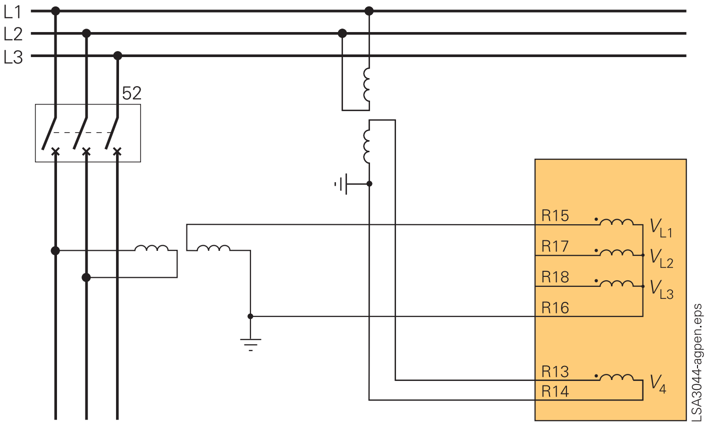


Fig. 10/18
Typical voltage transformer connection for synchro-check with single voltage dead line check

Technical data

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz (selectable)
Rated current I_{nom}	1 or 5 A (selectable)
Rated voltage V_{nom}	80 to 125 V (selectable)
Power consumption With I_{nom} = 1 A With I_{nom} = 5 A Voltage inputs	 Approx. 0.05 VA Approx. 0.30 VA ≤ 0.10 VA
Overload capacity of current circuit Thermal (r.m.s.) Dynamic (peak value)	 500 A for 1 s 150 A for 10 s 20 A continuous 1250 A (half cycle)
Thermal overload capacity of voltage circuit	230 V continuous
Auxiliary voltage	
Rated voltages	24, 48 V DC 60, 125 V DC 110, 250 V DC and 115, 230 V AC (50/60 Hz)
Permissible tolerance	-20 % to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption Quiescent Energized	 Approx. 5 W Approx. 8 W to 14 W, depending on design
Bridging time during failure of the auxiliary voltage For V_{aux} = 48 V and V_{aux} ≥ 110 V For V_{aux} = 24 V and V_{aux} = 60 V	 ≥ 50 ms ≥ 20 ms
Binary inputs	
Quantity 7VK610 7VK611	 7 20
Rated voltage range	24 to 250 V, bipolar
Pickup threshold	19 or 88 V or 176 V DC, bipolar
Functions are freely assignable	
Minimum pickup voltage Ranges are settable by means of jumpers for each binary input	19 or 88 V or 176 V DC, bipolar (3 operating ranges)
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Input impulse suppression	220 nF coupling capacitance at 220 V with a recovery time >60 ms

1) Can be set via jumpers.

Output contacts	
"Unit ready" contact (live status contact)	1 NC/NO contact[1)]
Command/indication relay	
Quantity 7VK610 7VK611	 5 NO contacts, 17 NO contacts, 1 NC/NO contacts[1)]
NO/NC contact	
Switching capacity Make Break, contacts Break, contacts (for resistive load) Break, contacts (for τ = L/R ≤ 50 ms)	 1000 W / VA 30 VA 40 W 25 VA
Switching voltage	250 V
Permissible total current	30 A for 0.5 seconds 5 A continuous
Operating time, approx. NO contact NO/NC contact (selectable)	 8 ms 8 ms
LEDs	
Quantity RUN (green) ERROR (red) LED (red), function can be assigned 7VK610 7VK611	 1 1 7 14
Unit design	
Housing	7XP20
Dimensions	Refer to part 16 for dimension drawings
Degree of protection acc. to EN 60529 Surface-mounting housing Flush-mounting housing Front Rear For the terminals	 IP 51 IP 51 IP 50 IP 20 with terminal cover put on
Weight Flush-mounting housing 1/3 x 19" 1/2 x 19" Surface-mounting housing 1/3 x 19" 1/2 x 19"	 5 kg 6 kg 9.5 kg 11 kg

Technical data

Serial interfaces	
***Operating interface,** front of unit for DIGSI 4*	
Connection	Non-isolated, RS232, 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115200 baud setting as supplied: 38400 baud; parity 8E1
Time synchronization DCF77/ IRIG-B signal (Format IRIG-B000)	
Connection	9-pin subminiature connector (SUB-D) (terminal with surface-mounting housing)
Voltage levels	5 V, 12 V or 24 V (optional)
Service/modem interface for DIGSI 4 / modem / service	
Isolated RS232/RS485 Dielectric test Distance for RS232 Distance for RS485	9-pin subminiature connector (SUB-D) 500 V / 50 Hz Max. 15 m Max. 1000 m
System interface	
	IEC 60870-5-103 protocol PROFIBUS-FMS PROFIBUS-DP DNP 3.0
Isolated RS232/RS485 Baud rate Dielectric test Distance for RS232 Distance for RS485	9-pin subminiature connector (SUB-D) 4800 to 38400 baud 500 V / 50 Hz Max. 15 m Max. 1000 m
PROFIBUS RS485 Dielectric test Baud rate Distance	 500 V / 50 Hz Max. 12 Mbaud 1000 m at 93.75 kbaud; 100 m at 12 Mbaud
PROFIBUS fiber-optic Only for flush-mounting housing For surface-mounting housing Baud rate Optical wavelength Permissible attenuation Distance	 ST connector Optical interface with OLM[1)] Max. 1.5 Mbaud $\lambda = 820$ nm Max. 8 dB for glass-fiber 62.5/125 µm 500 kB/s 1.6 km 1500 kB/s 530 m

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) IEEE C37.90.0/.1/.2 VDE 0435 For further standards see “Individual tests”
Insulation tests	
Standards	IEC 60255–5 and 60870-2-1
Voltage test (100 % test)	
All circuits except for auxiliary supply, binary inputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50 Hz
Auxiliary voltage and binary inputs (100 % test)	3.5 kV DC
RS485/RS232 rear side communication interfaces and time synchronization interface (100 % test)	500 V (r.m.s.), 50 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	 5 kV (peak); 1.2/50 µs; 0.5 J, 3 positive and 3 negative impulses in intervals of 5 s
***EMC tests for noise immunity;** type tests*	
Standards	IEC 60255-6; IEC 60255-22 (product standard) EN 61000-6-2 (generic standard), VDE 0435 Part 303, DIN VDE 0435-110
High-frequency test IEC 60255-22-1 class III and VDE 0435 Part 303, class III	2.5 kV (peak); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV and EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; $R_i = 330\ \Omega$
Irradiation with RF field, IEC 60255-22-3 class III IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, IEC 60255-22-3, IEC 61000-4-3 Amplitude-modulated Pulse-modulated	Class III, 10 V/m 80; 160; 450; 900 MHz; 80 % AM 1kHz; duration >10 s 900 MHz, 50 % PM, repetition frequency 200 Hz
Fast transient disturbance/bursts IEC 60255-22-4 and IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; test duration 1 min

1) Conversion with external OLM
Fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order code L0A (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Technical data

High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω; 9 µF Differential (transversal) mode:1 kV; 2 Ω: 18 uF
Measurement inputs, binary inputs, binary output relays	Common (longitudinal) mode: 2 kV; 42 Ω; 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω; 0.5 µF
Line-conducted HF, amplitude-modulated, IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability, IEEE C37.90.1	2.5 kV (peak); 1 MHz 400 surges per second, duration 2 s, $R_i = 200\ \Omega$
Fast transient surge withstand capability, IEEE C37.90.1	4 kV; 5/50 ns; 5 kHz burst length = 15 ms; repetition rate 300 ms; both polarities; $R_i = 50\ \Omega$; duration 1 min
Radiated electromagnetic interference IEEE C37.90.2	35 V/m; 25 to 1000 MHz,
Damped oscillation IEC 60694, IEC 61000-4-12	2.5 kV (peak value); polarity alternating 100 kHz; 1 MHz; 10 and 50 MHz; $R_i = 200\ \Omega$
***EMC tests for interference emission;** type tests*	
Standard	EN 50081-* (generic standard)
Conducted interference voltage on lines, only auxiliary voltage IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Radio interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress test

Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255–21 and IEC 60068–2
Vibration IEC 60255–21–1, class 2 IEC 60068–2–6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255–21–2, class 1 IEC 60068–2–27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Seismic vibration IEC 60255–21–3, class 1 IEC 60068–3–3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255–21 and IEC 60068–2
Vibration IEC 60255–21–1, class 2 IEC 60068–2–6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration, frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255–21–2, class 1 IEC 60068–2–27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks on each of the 3 axes in both directions
Continuous shock IEC 60255–21–2, class 1 IEC 60068–2–29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks on each of the 3 axes in both directions

Climatic stress tests

Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	-25 °C to +85 °C / -13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h (Legibility of display may be impaired above +55 °C / +131 °F)	-20 °C to +70 °C / -4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	-5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	-25 °C to +55 °C / -13 °F to 131 °F
– Limiting temperature during transport	-25 °C to +70 °C / -13 °F to +158 °F
Humidity	
Permissible humidity stress: It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation.	Annual average on ≤ 75 % relative humidity; on 56 days per year up to 93 % relative humidity; condensation is not permitted.

Technical data

Functions	
Auto-reclosure *(ANSI 79)*	
Number of auto-reclosures	Up to 8
Operating mode	Only 1-pole; only 3-pole, 1- or 3-pole
Operating modes with line voltage check	DLC – dead-line check ADT – adaptive dead time RDT – reduced dead time
Dead times $T_{1\text{-ph}}$, $T_{3\text{-ph}}$, T_{Seq}	0 to 1800 s (step 0.01 s) or deactivated
Action times	0.01 to 300 s (step 0.01 s) or deactivated
Reclaim times	0.5 to 300 s (step 0.01 s)
Start-signal monitoring time	0.01 to 300 s (steps 0.01 s)
Additional functions	Synchro-check request 3-phase intertripping InterCLOSE command to the remote end Check of CB ready state Blocking with manual CLOSE
Voltage limit values for DLC, ADT, RDT	
Healthy line voltage $_{\text{PH-E}}$	30 to 90 V (steps 1 V)
Dead line voltage $_{\text{PH-E}}$	2 to 70 V (steps 1 V)
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 3 % of setting value or 1 V
Synchro-check *(ANSI 25)*	
Initiate options	Auto-reclosure; Manual CLOSE control Control commands
Operating modes	
With auto-reclosure	Synchro-check Line dead/busbar live Line live/busbar dead Line and busbar dead Bypassing
For manual closure and control commands	As for auto-reclosure
Permissible voltage difference	1 to 40 V (step 0.1 V)
Permissible frequency difference	0.03 to 2 Hz (step 0.01 Hz)
Permissible angle difference	2 to 80 ° (step 1°)
Max. duration of synchronization	0.01 to 600 s (steps 0.01 s) or deactivated
Release delay with synchronous networks	0 to 30 s (steps 0.01 s)
Minimum measuring time	Approx. 80 ms
Tolerances	
Time stages	1 % of setting value or 10 ms
Voltage limit values	≤ 2 % of setting value or 1 V

Breaker failure protection *(ANSI 50BF)*	
Number of stages	2
Pickup of current element	0.05 to 20 A $_{(1A)}$ / 0.25 to 100 A $_{(5A)}$ (step 0.01 A)
Time delays $T1_{\text{1phase}}$, $T1_{\text{3phase}}$, $T2$	0 to 30 s (steps 0.01 s) or deactivated
Dropout (overshoot) time, internal	≤ 15 ms, typical; 25 ms, max.
End-fault protection	For fault between open CB and CT, with intertrip to the remote line end
Pole discrepancy supervision	Initiation if not all CB poles are closed or open
Monitoring time	0 to 30 s (steps 0.01 s) or deactivated
Tolerances	
Current limit value	≤ 5 % of setting value or 1 % I_{nom}
Time stages	1 % of setting value or 10 ms
Voltage protection *(ANSI 59, 27)*	
Operating modes	Local tripping and/or carrier trip for remote end
Overvoltage protection	
Pickup values $V_{\text{PH-E}}$>>, $V_{\text{PH-E}}$> (phase-earth overvoltage)	1 to 170 V (step 0.1 V)
Pickup values $V_{\text{PH-PH}}$>>, $V_{\text{PH-PH}}$> (phase-phase overvoltage)	2 to 220 V (step 0.1 V)
Pickup values $3V_0$>>, $3V_0$> ($3V_0$ can be measured via V4 transformers or calculated by the relay) (zero-sequence overvoltage)	1 to 220 V (step 0.1 V)
Pickup values V_1>>, V_1> (positive-sequence overvoltage)	2 to 220 V (step 0.1 V)
Pickup values V_2>>, V_2> (negative-sequence overvoltage)	2 to 220 V (step 0.1 V)
Reset ratio (settable)	0.5 to 0.98 (step 0.01)
Undervoltage protection	
Pickup values $V_{\text{PH-E}}$<<, $V_{\text{PH-E}}$< (phase-earth undervoltage)	1 to 100 V (step 0.1 V)
Pickup values $V_{\text{PH-PH}}$<<, $V_{\text{PH-PH}}$< (phase-phase undervoltage)	1 to 170 V (step 0.1 V)
Pickup values V_1<<, V_1< (positive-sequence undervoltage)	1 to 100 V (step 0.1 V)
Blocking of undervoltage protection stages	Minimum current; binary input
Reset ratio	1.05
Time delays	
Time delay for all stages	0 to 100 s (step 0.01 s) or deactivated
Command / pickup time	Approx. 34 ms at f_{nom} = 50 Hz Approx. 30 ms at f_{nom} = 60 Hz
Tolerances	
Voltage limit values	≤ 3 % of setting value or 1 V
Time stages	1 % of setting value or 10 ms
Trip circuit supervision *(ANSI 74TC)*	
Number of supervisable trip circuits	Up to 3
Number of required binary inputs per trip circuit	1 or 2
Indication relay	1 to 30 s (steps 1 s)

10

Technical data

Additional functions	
Operational measured values	
Representation	Primary, secondary and percentage referred to rated value
Currents	3 x I_{Phase} ; $3I_0$; I_1; I_2
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % I_{nom}
Voltages	3 x $V_{Phase\text{-}Earth}$; 3 x $V_{Phase\text{-}Phase}$; $3V_0$, V_1, V_2, V_{SYNC}, V_{en}
Tolerances	≤ 0.5 % of indicated measured value or 0.5 % V_{nom}
Power with direction indication	P, Q, S
Tolerances	
P: for $\lvert\cos\varphi\rvert$ = 0.7 to 1 and V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1%
Q: for $\lvert\sin\varphi\rvert$ = 0.7 to 1 and V/V_{nom} , I/I_{nom} = 50 to 120 %	Typical ≤ 1%
S: for V/V_{nom}, I/I_{nom} = 50 to 120 %	Typical ≤ 1%
Frequency	f
Tolerance	≤ 10 mHz
Power factor	PF
Tolerance for $\lvert\cos\varphi\rvert$ = 0.7 to 1	Typical ≤ 0.02
Energy meters	
Four-quadrant meters	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance for $\lvert\cos\varphi\rvert$ > 0.7 and V > 50 % V_{nom} and I > 50 % I_{nom}	5 %
Oscillographic fault recording	
Analog channels	3 x I_{Phase}, $3I_0$ 3 x V_{Phase}, $3V_0$, V_{SYNC}, V_{en}
Max. number of available recordings	8, backed-up by battery if auxiliary voltage supply fails
Sampling intervals	20 samplings per cycle
Total storage time	Approx. 15 s
Binary channels	Pickup and trip information; number and contents can be freely configured by the user
Max. number of displayed binary channels	40
Control	
Number of switching units	Depends on the number of binary / indication inputs and indication / command outputs
Control commands	Single command / double command 1, 1 plus 1 common or 2 pole
Feed back	CLOSE, TRIP, intermediate position
Interlocking	Freely configurable
Local control	Control via menu, function keys, control keys (if available)
Remote control	Control protection, DIGSI, pilot wires

Further additional functions	
Measured value supervision	Current sum Current symmetry Voltage sum Voltage symmetry Phase sequence Fuse failure monitor
Indications	
Operational indications	Buffer size 200
System disturbance indication	Storage of indications of the last 8 faults, buffer size 600
Switching statistics	Number of breaking operations per CB pole Sum of breaking current per phase Breaking current of last trip operation Max. breaking current per phase
Circuit-breaker test	TRIP/CLOSE cycle, 3 phases TRIP/CLOSE per phase
Dead time for CB TRIP / CLOSE cycle	0 to 30 s (steps 0.01 s)
Commissioning support	Operational measured values, CB test, status display of binary inputs, setting of output relays, generation of indications for testing serial interfaces
Phase rotation adjustment	Clockwise or anti-clockwise

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the national regulation VDE 0435.

Further applicable standards: IEEE C37.90.0 and C37.90.1.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081 and EN 61000-6-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Order code
7VK61 breaker management relay	7VK61□□ – □□□□□ – 4Y□0	□□□

Housing, binary inputs (BI) and outputs (BO)

Description	Order No.	Order code
Housing 1/3 19”, 7 BI, 6 BO incl. 1 live-status contact,	0	
Housing 1/2 19”, 20 BI, 19 BO incl. 1 live-status contact	1	

Measuring inputs (4 x V, 4 x I)

Description	Order No.	Order code
I_{ph} = 1 A, I_e = 1 A (min. = 0.05 A)[1]	1	
I_{ph} = 5 A, I_e = 5 A (min. = 0.25 A)[1]	5	

Rated auxiliary voltage (power supply, threshold of binary inputs)

Description	Order No.	Order code
24 to 48 V DC, binary input threshold 19 V[3]	2	
60 to 125 V DC[2], binary input threshold 19 V[3]	4	
110 to 250 V DC[2], 115 to 230 V AC, binary input threshold 88 V[3]	5	
220 to 250 V DC[2], 115 to 230 V AC, binary input threshold 176 V[3]	6	

Unit version

Description	Order No.	Order code
For panel flush mounting	A	
For panel surface mounting	E	

Region-specific default settings/language settings and functions versions

Description	Order No.	Order code
Region DE, language: German, selectable	A	
Region World, language: English, selectable	B	
Region US, language:US-English, selectable	C	
Region FR, language: French, selectable[4]	D	
Region World, language: Spanish, selectable[4]	E	
Region World, language: Italian, selectable[4]	F	

Port B system interface

Description	Order No.	Order code
Empty	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, double ring, ST connector[5]	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm , double ring, ST connector[5]	9	L 0 B
DNP 3.0, RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector[5]	9	L 0 H

Port C service interface

Description	Order No.	Order code
DIGSI 4/modem, electrical RS232	1	
DIGSI 4/modem, electrical RS485	2	

Functions

Breaker failure protection 1-/3-pole or 3-pole only	Auto-reclosure 1-/3-pole or 3-pole only and synchro-check	Over/Undervoltage protection	Order No.
■			C
■		■	D
	■		N
	■	■	P
■	■		Q
■	■	■	R

1) Rated current can be selected by means of jumpers.

2) Transition between the 3 auxiliary ranges can be selected by means of jumpers.

3) The binary input thresholds are selectable in 3 steps by means of jumpers.

4) Language versions on request.

5) Optical interfaces are not available with surface mounting housings (position 9 = E). Please order the version with RS485 interface and a separate electrical/optical converter.

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA 4 (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*
Connecting cable (copper) Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*
Voltage transformer miniature circuit-breaker Rated current 1.6 A; thermal overload release 1.6 A; overcurrent trip 6 A	*3RV1611-1AG14*
Manual for 7VK61 English	*C53000-G1176-C159-1*
German	*C53000-G1100-C159-1*
French	*C53000-G1177-C159-1*

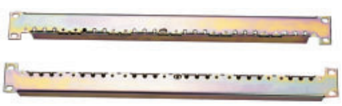


Fig. 10/19 Mounting rail for 19" rack

Fig. 10/20
2-pin connector

Fig. 10/21
3-pin connector

Fig. 10/22
Short-circuit link for current contacts

Fig. 10/23
Short-circuit link for voltage contacts/ indications contacts

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	10/20
	3-pin	*C73334-A1-C36-1*	1	Siemens	10/21
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP [1]	
		0-827396-1	1	AMP [1]	
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP [1]	
		0-827397-1	1	AMP [1]	
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP [1]	
		0-163084-2	1	AMP [1]	
Crimping tool	For type III+	*0-539635-1*	1	AMP [1]	
	and matching female	*0-539668-2*		AMP [1]	
	for CI2	*0-734372-1*	1	AMP [1]	
	and matching female	*1-734387-1*		AMP [1]	
19" mounting rail		*C73165-A63-D200-1*	1	Siemens	10/19
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	10/22
	For other terminals	*C73334-A1-C34-1*	1	Siemens	10/23
Safety cover for terminals	large	*C73334-A1-C31-1*	1	Siemens	10/4
	small	*C73334-A1-C32-1*	1	Siemens	10/4

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

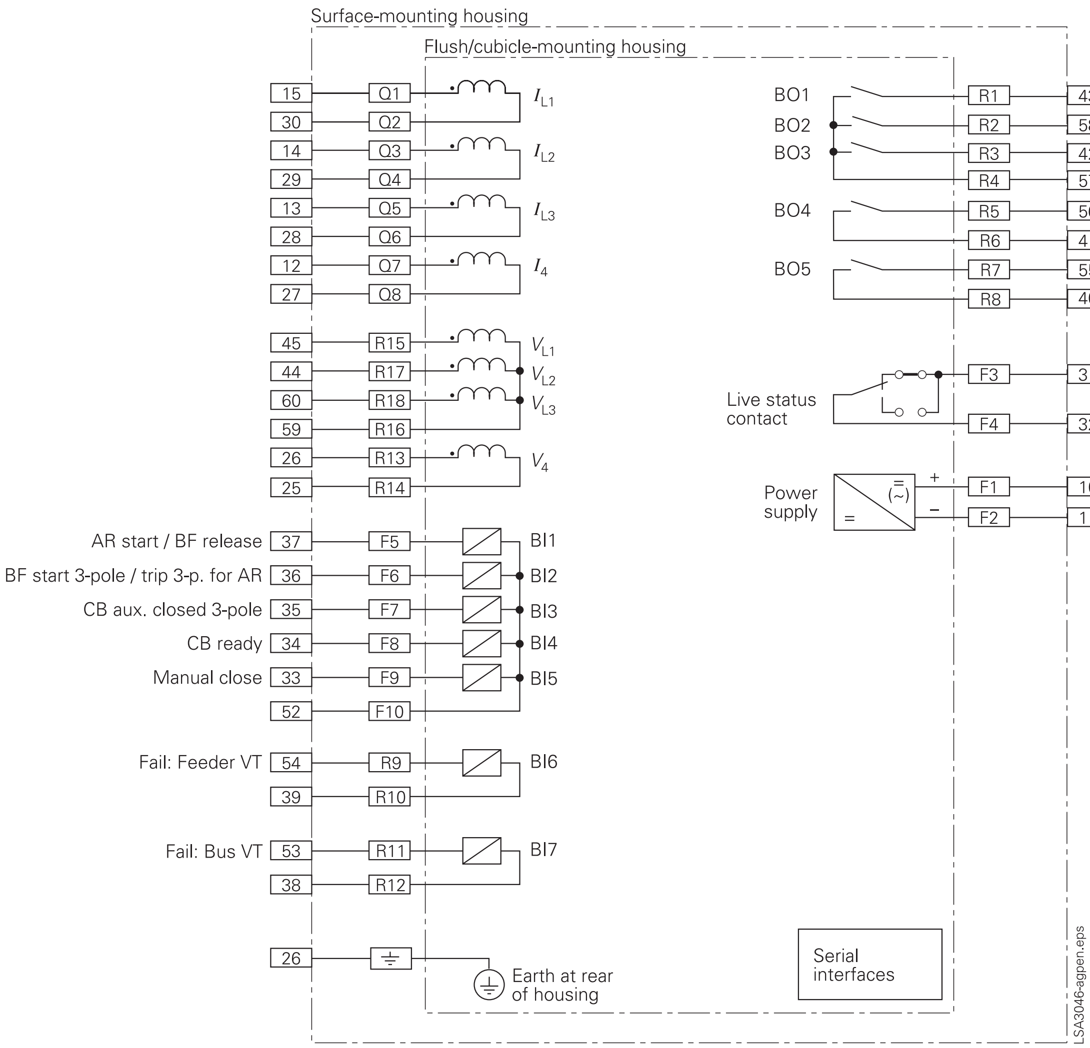


Fig. 10/24
Connection diagram 7VK610, 1/3 x 19" housing

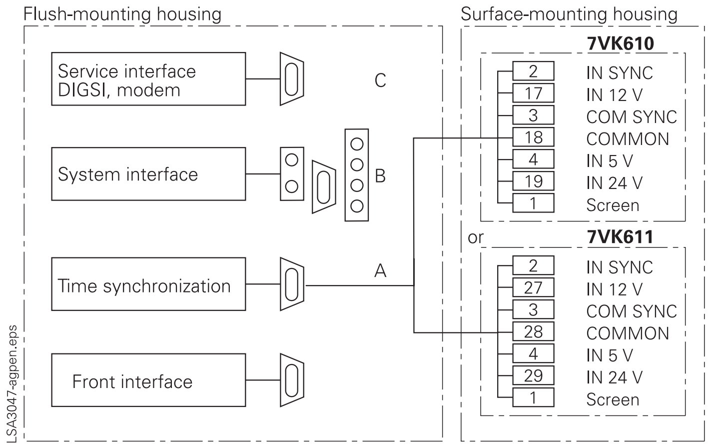


Fig. 10/25
Serial interfaces

Connection diagram

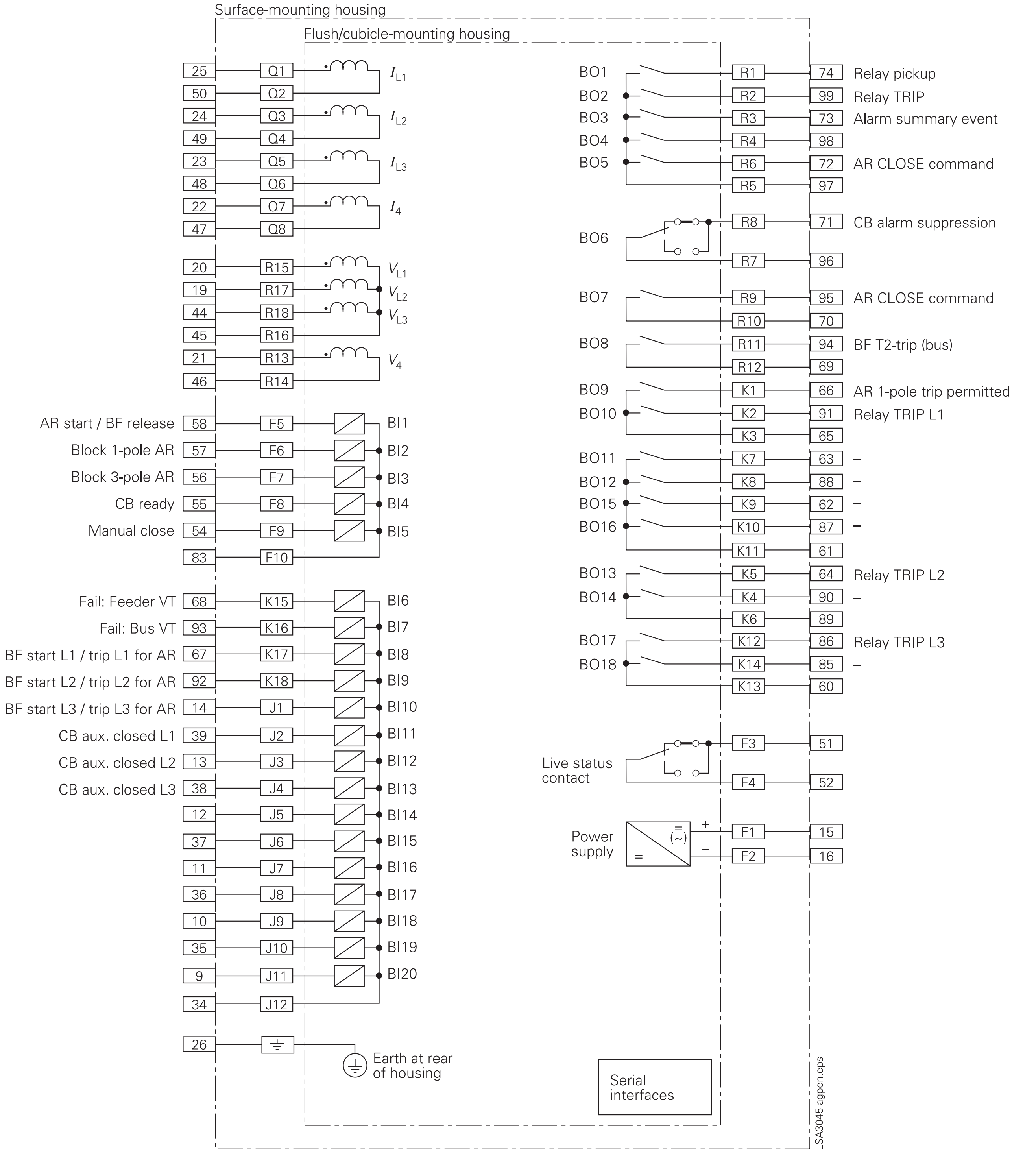


Fig. 10/26
Connection diagram 7VK611, 1/2 x 19″ housing

SIPROTEC 7SV600
Numerical Circuit-Breaker Failure Protection Relay

Fig. 10/27
SIPROTEC 7SV600 numerical circuit- breaker failure protection relay

Description

The SIPROTEC 7SV600 is a numerical relay used for circuit-breaker failure protection. A failure occurs when the circuit-breaker fails to correctly open and clear the fault after single or three-pole trip commands have been issued by the protection unit. It is then necessary to trip the relevant busbar zone (section) to ensure fault clearance.

Generally, the monitoring of the current is sufficient as the criterion for the indication that the circuit-breaker has successfully cleared the fault ("current condition"). However, under certain fault conditions (e.g. overvoltage), little or no current may flow, making the measurement of current unreliable for indication of the circuit-breaker status ("no current condition"). The 7SV600 operates correctly for both these conditions. The relay is suitable for use at all voltage levels and in all applications. The current transformers can either be of the closed iron core or linear type. The relay can be incorporated in conventional switchgear systems and modem substation control systems e.g. SICAM.

Function overview

Protection functions

- Circuit-breaker failure protection (single or three-pole with/without current)
- Independently settable delay times for operation with and without current
- Single or two-stage time delay of the busbar trip command
- Re-trip (cross trip) stage (1st stage of the 2-stage operation)
- Intertrip facility (via teleprotection interface)
- End-fault protection with intertrip
- "No current" control using the circuit-breaker auxiliary contacts

Features

- Highly sensitive current detection
- 2-out-of-4 check of the current detectors
- Short reset time, negligible overshoot time
- Can be initiated by phase-segregated or common-phase trip commands
- End-fault protection
- Assignable output relays, LEDs and binary inputs

Monitoring functions

- Monitoring of circuit-breaker auxiliary contacts
- Operational current measured values
- Self-supervision of the relay
- Event buffer
- Fault protocols
- Oscillographic fault recording

Communication interfaces

- 1 x RS485 interface
  – IEC 60870-5-103 protocol
  – DIGSI

Hardware

- Digital inputs:
  – 3 binary inputs
- Digital outputs:
  – 4 output relays

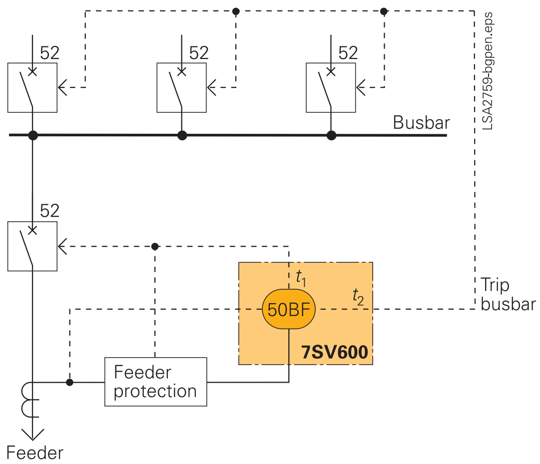
Front design

- Display for operation and measured values
- 6 LEDs for local alarm

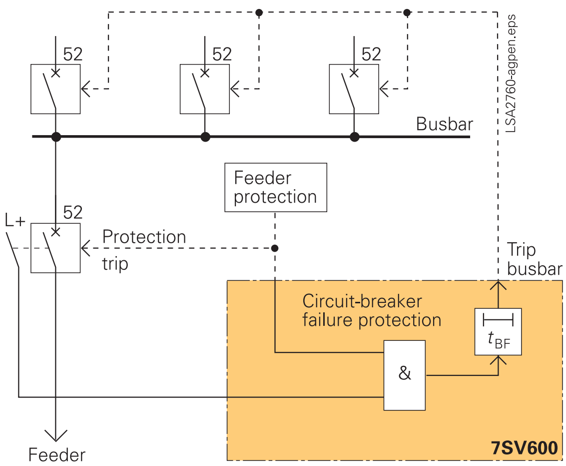
Application

The numerical circuit-breaker failure protection relay 7SV600 provides rapid backup fault clearance instruction to the associated circuit-breakers in case the circuit-breaker nearest to the fault fails to respond.

It is suitable for power systems of all voltage levels. The initiation signal can be derived from any protection or supervision equipment or, in case of manual opening, from the control discrepancy switch of the breaker. Information from the circuit-breaker auxiliary contact is required for the breaker failure protection to function during faults which produce little or no current flow (possible only with common-phase initiation).



Simplified application diagram of circuit-breaker failure protection.



Simplified application diagram of circuit-breaker failure protection by means of a circuit-breaker auxiliary contact.

Fig. 10/28 Typical applications

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Input and evaluation of binary signals
- SCADA interface (RS485)
- Power supply

The rated CT currents applied to the SIPROTEC 7SV600 can be 1 or 5 A. This is selectable via a jumper inside the relay.

Three different housings are available. The flush-mounting versions have terminals accessible from the rear. The surface-mounting version has terminals accessible from the front.

Fig. 10/29
Rear view of surface-mounting housing

Protection functions

The breaker failure protection can operate single-stage or two-stage. When used as single-stage protection, the bus trip command is given to the adjacent circuit-breakers if the protected feeder breaker fails. When used as two-stage protection, the first stage can be used to repeat the trip command to the relevant feeder breaker, normally on a different trip coil, if the initial trip command from the feeder protection is not successful. The second stage will result in a bus trip to the adjacent breakers, if the command of the first stage is not successful.

The bus trip command from the breaker failure protection can be routed to all circuit-breakers linked to the same busbar (section) as the breaker that failed. It can also be transmitted to the remote end by means of a suitable communication link (e.g. PLC, radio wave, or optical fiber).

The isolator replica which is necessary in case of multiple busbar sections is not part of the 7SV600 relay.

The current level is monitored in each of the three phases against a set threshold. In addition, the zero-sequence component or the negative-sequence component of the phase currents derived by symmetrical component analysis is monitored. This ensures high security against malfunction by use of a 2-out-of-4 check of the current detectors.

The version with phase-segregated initiation enables reliable breaker failure detection even during single-pole auto-reclose cycles, provided the phase-segregated trip signals of the feeder protection are connected to the 7SV600.

If the protected circuit-breaker is not operational (e.g. air pressure failure or spring not charged), instantaneous bus trip of the adjacent circuit-breakers can be achieved following a feeder protection trip, provided the relay is informed via binary input of the breaker status (possible only for common-phase initiation).

An end-fault protection function is integrated in the 7SV600 relay. An end fault is a short-circuit located between the circuit-breaker and the current transformer set of the feeder. For this fault, current flow is detected, although the auxiliary contacts of the breaker indicate open breaker poles. A command signal is generated which can be transmitted to the remote-end breaker (possible only for common-phase initiation).

Special measures are taken to prevent malfunction of the relay. Besides the mentioned 2-out-of-4 check of the current detection elements, the trip signals of the feeder protection can be connected in a redundant manner, so that they can be checked for plausibility (possible only for common-phase initiation).

Continuous monitoring of the measured values permits rapid annunciation of any fault in the instrument transformer circuits. Continuous plausibility monitoring of the internal measured value processing circuits and monitoring of the auxiliary voltages to ensure that they remain within tolerance are obviously inherent features.

Serial data transmission

A PC can be connected to ease setup of the relay using the Windows-based program DIGSI which runs under MS-Windows.

It can also be used to evaluate up to 8 oscillographic fault records, 8 fault logs and the operational event buffer. As an option, a system interface is available.

The SIPROTEC 7SV600 transmits a subset of data via IEC 60870-5-103 protocol:

- General fault detection of the device
- General trip of the device
- Current in phase L2 [%] =
- Breaker failure trip T1 (local trip)
- Breaker failure trip T2 (busbar trip)
- Circuit-breaker defective: Trip
- Trip by end-fault protection
- Trip by monitoring current symmetry
- Breaker failure protection is active

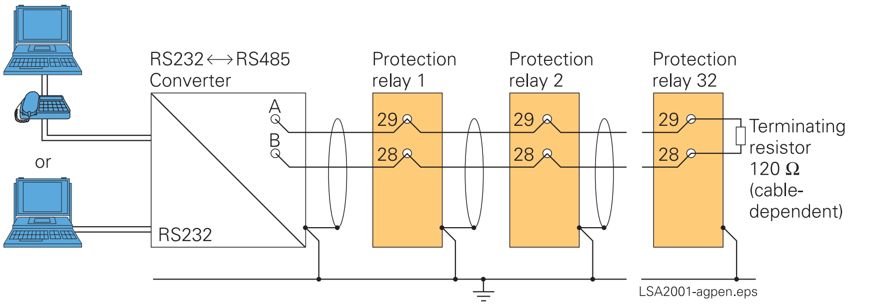


Fig. 10/30
Wiring communication RS485
For convenient wiring of the RS485 bus, use bus cable system 7XV5103 (see part 14 of this catalog)

Connection diagrams

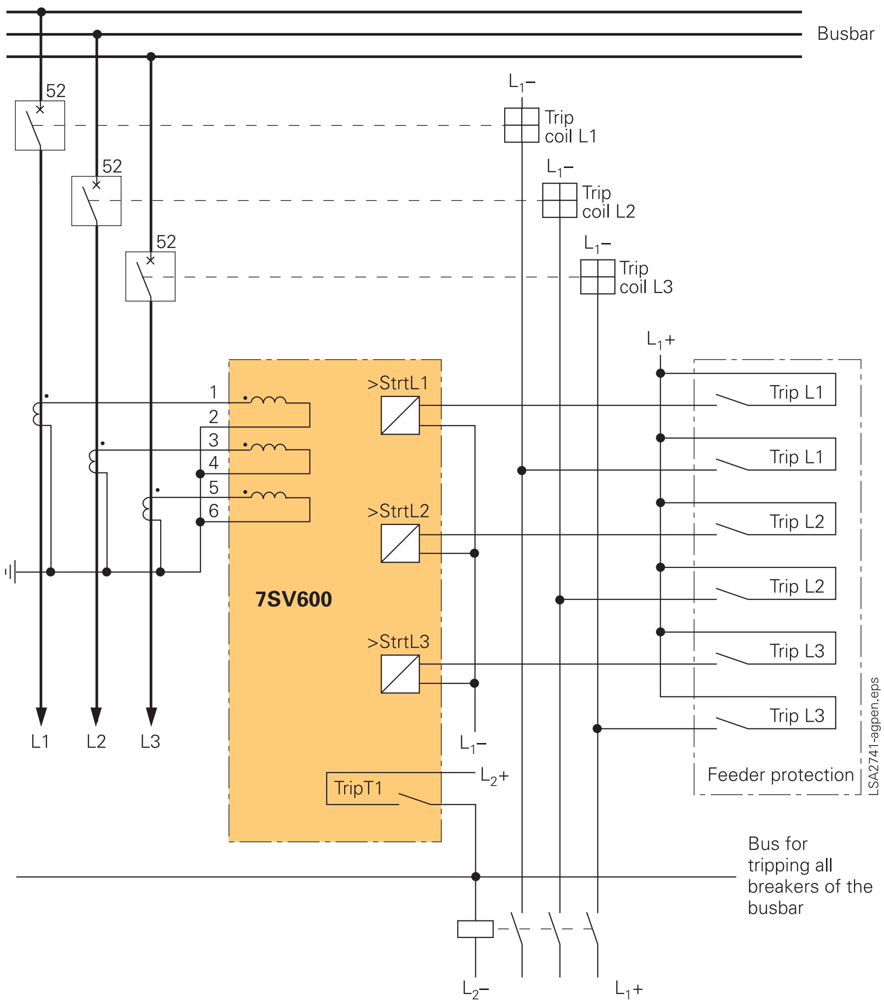


Fig. 10/31
Connection example for single-stage breaker failure protection with phase-segregated initiation

Connection diagrams

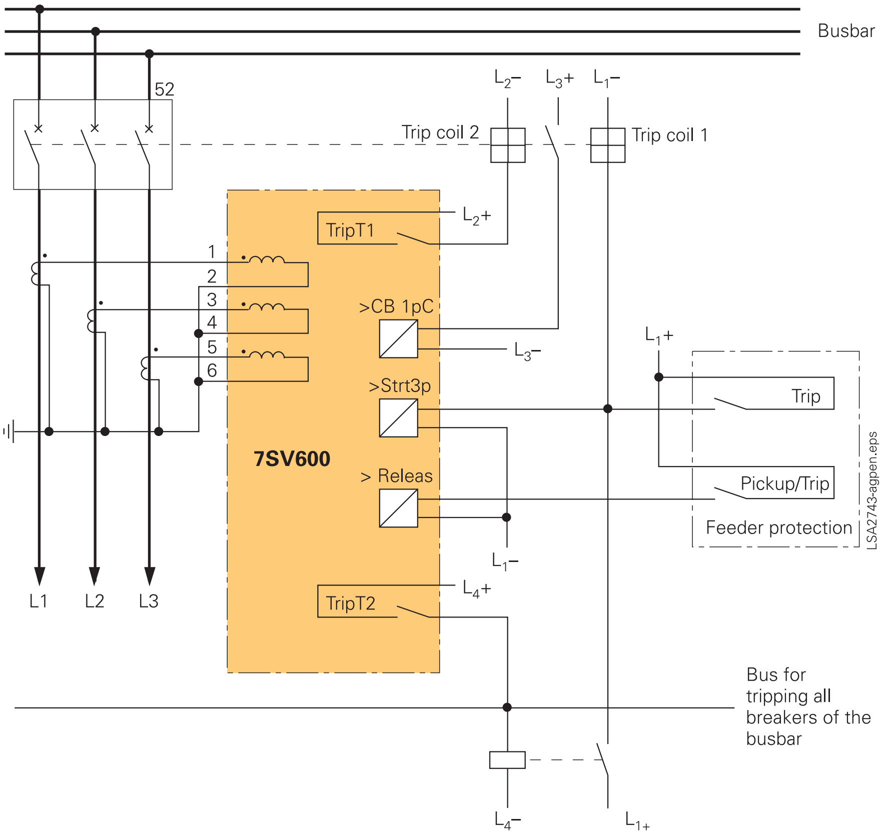


Fig. 10/32
Connection example for 2-stage breaker failure protection, common phase initiation, CB interrogation

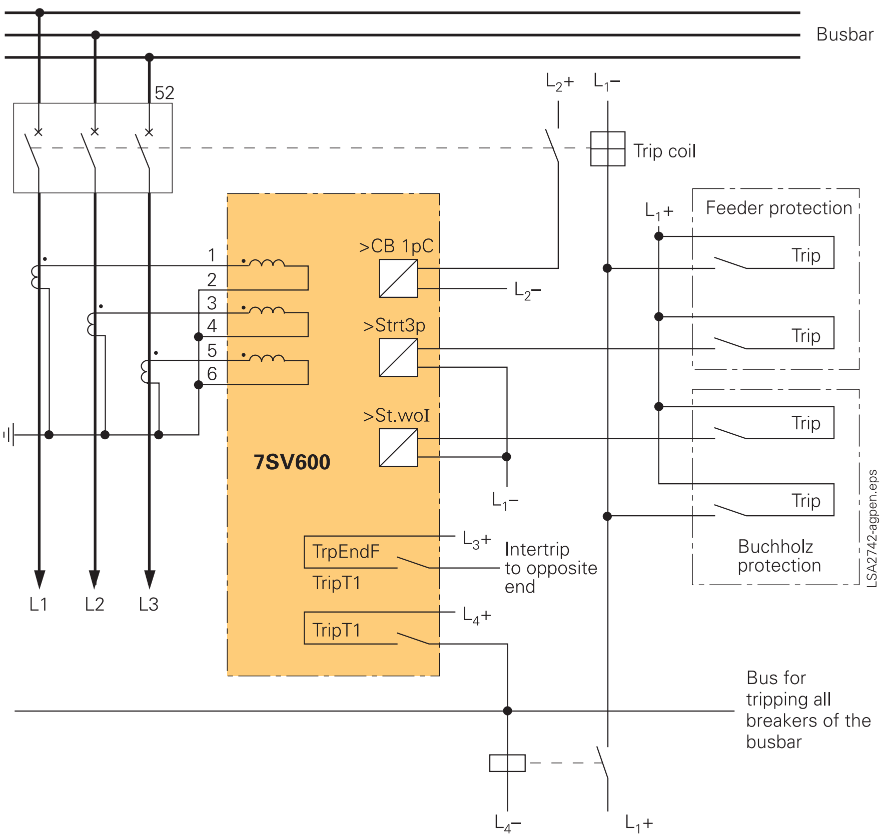


Fig. 10/33
Connection example for single-stage breaker failure protection with common phase initation and Buchholz protection, CB interrogation is imperative; additional intertrip signal to the opposite line end in case of breaker failure or end fault

10

Technical data

General unit data	
Measuring circuits	
Rated current I_N	1 to 5 A
Rated frequency f_N can be parameterized	50 or 60 Hz (selectable)
Power consumption of current inputs	
At I_N = 1 A	< 0.1 VA
At I_N = 5 A	< 0.2 VA
Overload capability current path,	
Thermal (r.m.s.)	100 x I_N for ≤ 1 s 30 x I_N for ≤ 10 s 4 x I_N continuous
Dynamic (pulse current)	250 x I_N one half cycle
Auxiliary voltage	
Power supply via integrated DC/DC converter	
Rated auxiliary voltage V_{Aux} DC	24 / 48 V DC 60 / 110 / 125 V DC 220 / 250 V DC
Permissible variations	19 to 58 V DC 48 to 150 V DC 176 to 300 V DC
Superimposed	
AC voltage	≤ 12 % at rated voltage
Peak-to-peak	≤ 6 % at limits of admissible voltage
Power consumption	
Quiescent	Approx. 2 W
Energized	Approx. 4 W
Bridging time during failure/short-circuit of auxiliary voltage	≥ 50 ms at V_{rated} ≥ 110 V DC ≥ 20 ms at V_{rated} ≥ 24 V DC
Rated auxiliary voltage V_{Aux}	115 V AC, 50/60 Hz 230 V AC, 50/60 Hz
Permissible variations	92 to 133 V AC 184 to 265 V AC
Heavy duty (command) contacts	
Command (trip) relays, number	2 (can be marshalled)
Contacts per relays	2 NO
Switching capacity	
Make	1000 W / VA
Break	30 W / VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 s
Signal contacts	
Signal/alarm relays	2 (can be marshalled)
Contact per relays	1 CO
Switching capacity	
Make	1000 W/VA
Break	30 W/VA
Switching voltage	250 V
Permissible current	5 A

Binary inputs	
Number	3 (can be marshalled)
Rated operating voltage	24 to 250 V DC
Current consumption	Approx. 2.5 mA, independent of operating voltage
Pick-up threshold	selectable by plug-in jumpers
Rated aux. voltage 24/48/60 V DC	V_{pickup} ≥ 17 V DC $V_{drop\text{-}off}$ < 8 V DC
Rated aux. voltage 110/125/220/250 V DC	V_{pickup} ≥ 74 V DC $V_{drop\text{-}off}$ < 45 V DC
Unit design	
Housing	7XP20
Dimensions	Refer to part 16 for dimension drawings
Weight	
In housing for surface mounting	Approx. 4.5 kg
In housing for flush mounting	Approx. 4.0 kg
Degree of protection acc. to EN 60529	
Housing	IP 51
Terminals	IP 21
Serial interface	
Isolated	
Standard	RS485
Test voltage	2.8 kV DC
Connection	Data cable on terminals, two data wires, one frame reference, for connection of a personal computer or similar; core pairs with shield, shield must be earthed; communication possible via modem
Baud rate	As delivered 9600 baud min. 1200 baud; max. 19200 baud

Electrical tests	
Specifications	
Standards	IEC 60255-5; ANSI/IEEE C37.90.0
Insulation tests	
High voltage test (routine test) except DC voltage supply input and RS485	2 kV (r.m.s.); 50 Hz
High voltage test (routine test) only DC voltage supply input and RS485	2.8 kV DC
High voltage test (type test)	
Between open contacts of trip relays	1.5 kV (r.m.s.), 50 Hz
Between open contacts of alarm relays	1 kV (r.m.s.), 50 Hz
Impulse voltage test (type test) all circuits, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s

Technical data

EMC tests for noise immunity; type tests	
Standards: IEC 60255-6, IEC 60255-22 (product standards); EN 50082-2 (generic standard) VDE 0435, part 303	
High frequency IEC 60255-22-1, class III	2.5 kV (peak); 1 MHz; τ =15 µs; 400 shots/s; duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge; 8 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with radio-frequency field, non-modulated; IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with radio-frequency field, amplitude-modulated; IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with radio-frequency field, pulse-modulated; IEC 61000-4-3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transients/bursts IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV; 5/50 ns; 5 kHz; burst length 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; duration 1 min
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV	 30 A/m continuous; 300 A/m for 3 s; 50 Hz
IEC 60255-6	0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 to 3 kV (peak); 1 to 1.5 MHz, decaying oscillation; 50 surges per s; duration 2 s; R_i = 150 Ω to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV; 10/150 ns; 50 surges per s; both polarities; duration 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m; 25 to 1000 MHz; amplitude and pulse modulated
High frequency test document 17C (SEC) 102	2.5 kV (peak, alternating polarity); 100 kHz, 1 MHz, 10 and 50 MHz, decaying oscillation; R_i = 50 Ω
EMC tests for interference emission; type tests	
Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage CISPR 22, EN 55022	150 to 30 MHz Limit class B
Radio interference field strength CISPR 11, EN 55011	30 to 1000 MHz Limit class A

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class I IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude; 60 to 150 Hz: 0.5 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I	Half-sine Acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 g acceleration (horizontal axis) 8 to 35 Hz: 0.5 g acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transportation	
Standard	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 g acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sine Acceleration 15 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sine Acceleration 10 g, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Technical data

Climatic stress tests

Temperatures	
Permissible temperature during service	–20 °C to +70 °C (> 55 °C decreased display contrast)
Recommended temperature during service	–5 °C to +55 °C
Permissible temperature during storage	–25 °C to +55 °C
Permissible temperature during transport Storage and transport with standard works packaging!	–25 °C to +70 °C
Humidity	
Permissible humidity We recommend that all units are installed such that they are not subjected to direct sunlight, nor to large temperature fluctuations which may give rise to condensation.	Mean value per year ≤ 75 % relative humidity; on 30 days per year 95 % relative humidity; condensation not permissible!

Service conditions

The relay is designed for use in industrial environment, for installation in standard relay rooms and compartments so that with proper installation electromagnetic compatibility (EMC) is ensured. The following should also be heeded:

- All contactors and relays which operate in the same cubicle or on the same relay panel as the digital protection equipment should, as a rule, be fitted with suitable spike quenching elements.
- All external connection leads in substations from 100 kV upwards should be shielded with a shield capable of carrying power currents and earthed at both sides. No special measures are normally necessary for substations of lower voltages.
- The shield of the RS485 cable must be earthed.
- It is not permissible to withdraw or insert individual modules under voltage. In the withdrawn condition, some components are electrostatically endangered; during handling the standards for electrostatically endangered components must be observed. The modules are not endangered when plugged in.

WARNING! The relay is not designed for use in residential, commercial or light-industrial environment as defined in EN 50081.

Functions

Breaker supervision	
Current detection	
Setting range	0.05 x I_N to 4.00 x I_N (steps 0.01 x I_N)
Drop-off ratio	Approx. 0.9
Tolerance	0.01 x I_N or 5 % of set value
Initiation conditions	
Depending on ordered version	Phase-segregated initiation (single-pole trip from feeder protection) or common-phase initiation (three-pole trip from feeder protection) and common-phase initiation (three-pole trip from non-short-circuit protection)
Times	
Pickup time	Approx. 15 ms with measured quantities present Approx. 25 ms after switch-on of measured quantities
Drop-off time with sinusoidal measured quantities	≤ 10 ms
Drop-off time maximum	≤ 25 ms
Delay times for all time stages	0.00 s to 32.00 s (steps 0.01 ms) or deactivated
Delay time tolerance	1 % of set value or 10 ms
The set times are pure delay times.	

Additional functions

Operational value measurements	
Operational current values Measurement range Tolerance	I_{L1}; I_{L2}; I_{L3} 0 % to 240 % I_N 3 % of rated value or of measured value
Steady-state measured value supervision	
Current unbalance	I_{max} / I_{min} > symmetry factor as long as $I > I_{limit}$
Fault event data storage	
Storage of annunciations of the last eight faults with max. 30 messages each	
Time assignment	
Resolution for operational annunciations	1 s
Resolution for fault event annunciations	1 ms
Max. time deviation	0.01 %
Data storage for fault recording (max. 8 fault events)	
Total storage time (fault detection or trip command = 0 ms)	Max. 5 s, selectable pre-trigger and post-fault time
Max. storage period per fault event T_{max}	0.30 to 5.00 s (steps 0.01 s)
Pre-trigger time T_{pre}	0.05 to 0.50 s (steps 0.01 s)
Post-fault time T_{post}	0.05 to 0.50 s (steps 0.01 s)
Sampling rate	1 instantaneous value per ms at 50 Hz 1 instantaneous value per 0.83 ms at 60 Hz

Selection and ordering data

Description	Order No.
7SV600 numerical circuit-breaker failure protection relay	*7SV600☐-☐☐A00-☐DA0*
Rated current; rated frequency	
1 A; 50/60 Hz	1
5 A; 50/60 Hz	5
Rated auxiliary voltage	
24, 48 V DC	2
60, 110, 125 V DC	4
220, 250 V DC / 115 V AC, 50/60 Hz	5
230 V AC, 50/60 Hz	6
Unit design	
For panel surface mounting with terminals on both sides	B
For panel surface mounting with terminals at top and bottom	D
For panel flush mounting/cubicle mounting	E
Options	
For common phase initiation	0
For common phase initiation or phase-segregated initiation	1

Accessories

DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows (version Windows 2000/XP Professional Edition) device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
*RS232 (V.24)↔RS485 converter**	*7XV5700-☐☐☐00*
Plug-in auxiliary power supply unit 220 V/50 Hz AC	0
Plug-in auxiliary power supply unit 110 V/60 Hz AC	1
With RS485 connecting cable for 7SJ6, 7RW6, 7SD6, 7SV6	A
With RS485 connecting cable with 9-pin connector for SIMEAS Q	B
With RS485 connecting cable with plug connector for SIMEAS T	C
Without RS232 connecting cable	A
With RS232 connecting cable 7XV5100-2 for PC/notebook, 9-pin connector (female)	B
With RS232 adapter, 25-pin connector (male) to 9-pin connector (female) for connection to notebook/PC	C
Converter full-duplex fiber-optic cable - RS485 With power supply 24 - 250 V DC and 110/230 V AC	7XV5650-0BA00
Manual for 7SV600 English	C53000-G1176-C123

*) RS485 bus system up to 115 kbaud
RS485 bus cable and adaptor
7XV5103-☐AA☐☐; see part 14.

Connection diagram

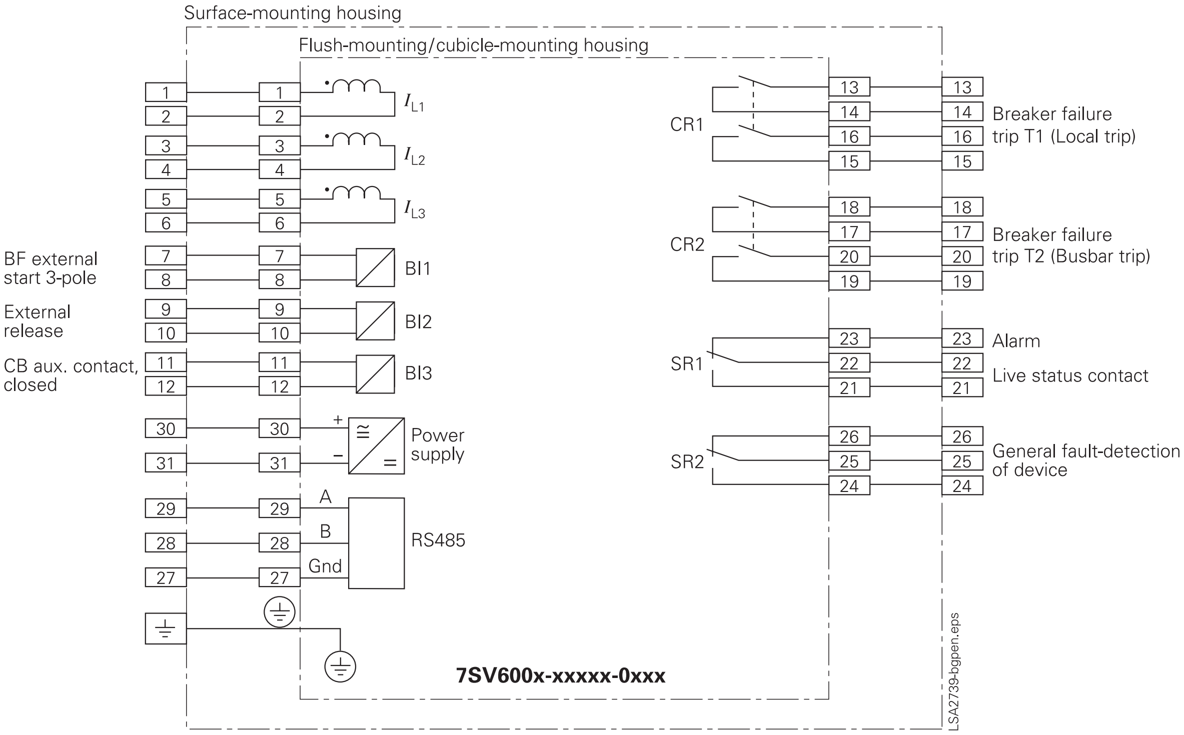


Fig. 10/34
General connection diagram of 7SV600 with presettings for common phase initiation

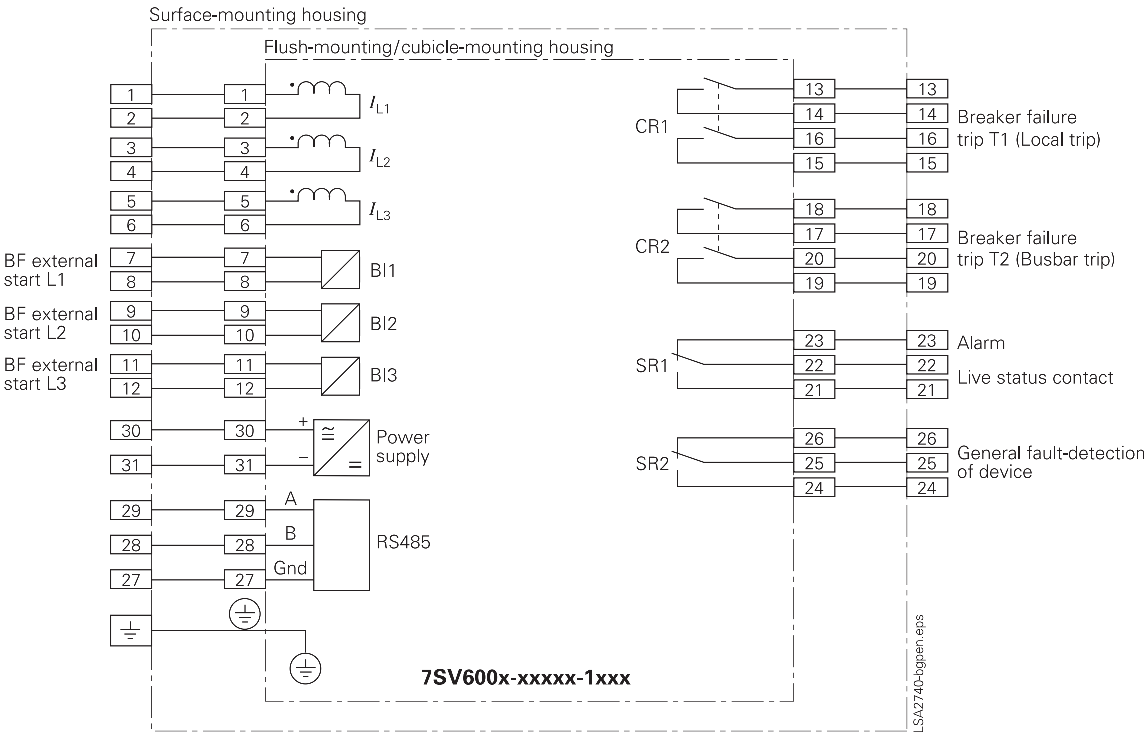


Fig. 10/35
General connection diagram of 7SV600 with presettings for phase-segregated initiation

SIPROTEC 7SN60
Transient Earth-Fault Protection Relay

Fig. 10/36 SIPROTEC 7SN60 transient earth-fault relay

Description

The highly sensitive 7SN60 transient earth-fault relay determines the direction of transient and continuous earth faults in systems with isolated neutral, in systems with high-impedance resistive earthing and in compensated systems. Continuous earth faults are indicated with a delay, either in conjunction with a transient earth fault and subsequently persisting displacement voltage, or with just the displacement voltage present.

Function overview

Protection functions

- Units for panel surface mounting or flush mounting in 7XP20 housing, with terminals on the side or terminals on the top/bottom
- Both fault directions indicated by LEDs and signaled by relays
- High pickup sensitivity due to separate detection and evaluation of total current and displacement voltage
- 1 A and 5 A rated current selectable for current transformer matching
- 16 selectable pickup thresholds for detection of transients in the current path, even with higher steady-state total currents of 10 to 300 mA
- Fixed pickup threshold of 5 V for detection of transients in the voltage path, even in the case of higher steady-state displacement voltages
- 4 selectable pickup thresholds for evaluation of the displacement voltage of 10 to 50 V
- Optional suppression of switching operations by evaluation of the displacement voltage after a switching-induced transient has occured
- Wide-range power supply for connection to 110/230 V AC systems, 60 to 250 V DC station batteries or 100 V DC voltage transformers without switchover or 24 to 60 V DC
- Binary inputs for remote reset and blocking with extremely wide input voltage range of 24 to 250 V DC
- Automatic reset of direction indications and signals after 3 or 10 s (selectable)
- Automatic reset in case of intermittent earth faults only after the last earth-fault, i.e. the correct indication and signal of the first earth fault is preserved
- Detection of the displacement voltage and earth-fault indication/signal, independent of a transient fault detection
- Signaling and indication of a continuous earth fault possible only in the forward direction
- Fault indication if sensitivity is set too high

10

Construction

The relay contains all the components needed for

- Acquisition and evaluation of measured values
- Operation and display
- Output of signals and trip commands
- Power supply

The rated CT currents applied to the SIPROTEC 7SN60 can be 1 or 5 A. This is selectable via a jumper inside the relay.

Three different housings are available. The flush-mounting/cubicle-mounting housings have terminals accessible from the rear. The surface-mounting housing has terminals either on the side or on the top and bottom.

Fig. 10/37 Rear view

Protection functions

Earth-fault directional determination

The highly sensitive 7SN60 transient earth-fault relay determines the direction of transient and continuous earth faults in systems with isolated neutral, in systems with high-impedance resistive earthing and in compensated systems.

Continuous earth faults are indicated with a delay, either in conjunction with a transient earth fault and subsequently persisting displacement voltage, or with just the displacement voltage present.

In the event of an earth fault, the neutral-point voltage to earth can be as high as the full-phase voltage.

The phase-to-earth capacitances of the non-earth-faulted phases are charged via the transformer inductance.

This charging process is bound up with a strong current surge (starting oscillation).

The amplitude of this current surge depends on the expands of the system and on the contact resistance values at the earth-fault location.

This current flows via the phase-to-earth capacitances of the unaffected lines to earth, enters the earth-faulted phase via the earth-fault location and flows back from there to the feeding transformer.

Thus the direction of the earth-fault induced current surge is identical to that of the short-circuit current at the same location.

At measuring point A, as a result of the transformer summation circuit, the earth current of the faulted line is not included in the measurement, as this current portion flows through the summation transformer of the relevant Holmgreen circuit and back, thereby canceling itself out.

It is the total of the capacitive earth currents from the non-faulted system which has an effect. In the diagram they are summated on the upper line. The capacitive currents of the non-faulted lines 1, 3 and 2, 4 accumulate vectorially, which explains why only three arrows instead of four are shown at the measuring point A.

With a transient earth fault, the equalizing current forming a damped oscillation of 100 to more than 1000 Hz decays after only a few periods.

The displacement voltage V_{EM} thereupon also returns to zero. In earthed systems this takes place after a number of periods (decay of the Petersen coil - earth capacitance oscillation circuit); in non-earthed systems this occurs after a very short time.

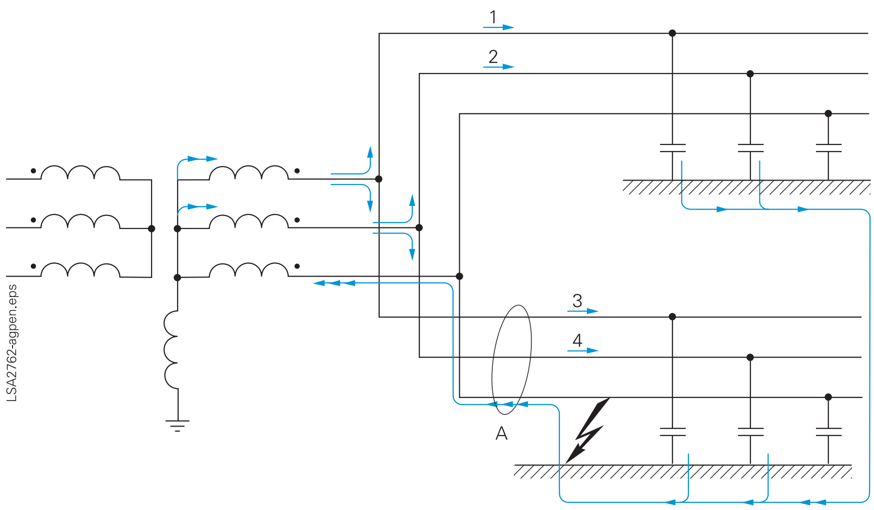


Fig. 10/38 Fault currents in the system

Protection functions

In the case of a continuous earth fault, the equalizing current in the non-earthed system changes into the mostly capacitive continuous earth current or, in compensated systems, into the relatively low residual active current.

For the directional determination, the direction of the first transient of neutral current and displacement voltage is considered.

The relay indicates the direction of the transient earth fault by LEDs (red = forward direction, yellow = reverse direction) and the relevant signaling relay pickups.

Continuous earth faults are indicated after a settable time by an LED on the relay and signaled by a signaling relay.

Detection of the fault location

If the system is of radial configuration, the red lamp immediately indicates the faulted line.

If one of the lines consists of several sections, the fault is upstream of the last red lamp.

The transient earth-fault relay can also be used without restrictions in any type of meshed systems. Transient earth-fault relays distributed at suitable points throughout the system allow detection of the earth-fault location from the directional indications.

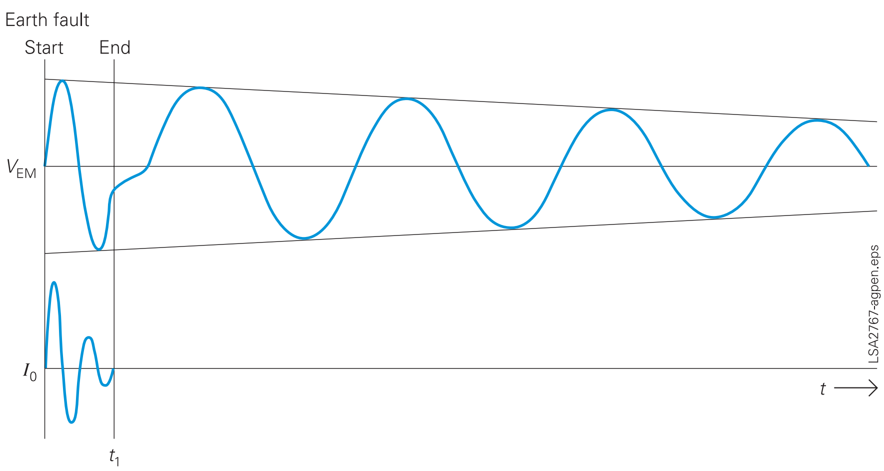


Fig. 10/39 Neutral current and displacement voltage

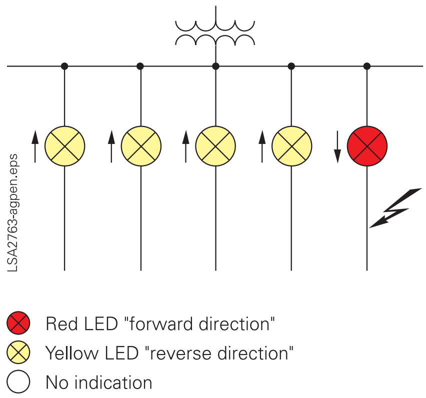


Fig. 10/40 Radial system

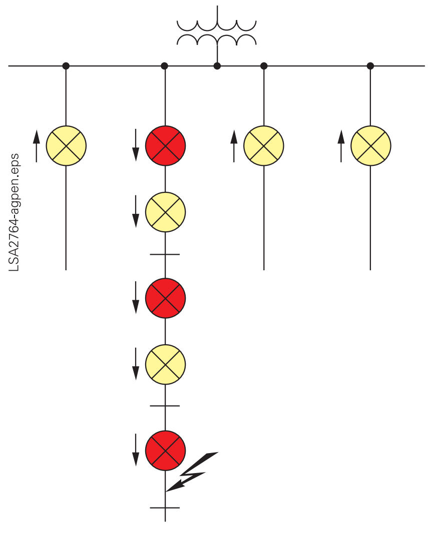


Fig. 10/41 Cascaded radial system

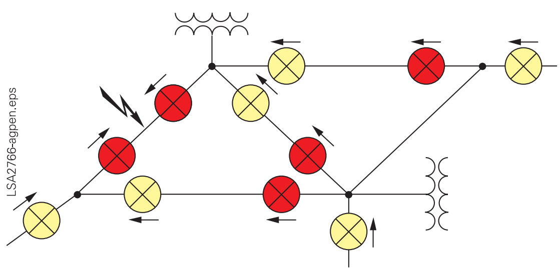


Fig. 10/42 Meshed system

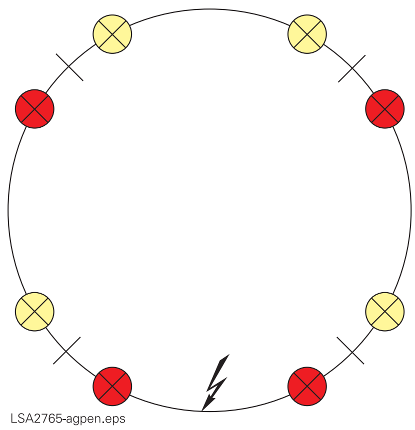


Fig. 10/43 Ring system

Typical connection

Connection of the current and voltage transformers

Figures 10/44 and 10/45 show the connection of the current and voltage transformer set in Holmgreen circuit.

In Fig. 10/44, the star point at the line-side of the CT must be connected to terminal 1 while the star point at the busbar side of the CTs must be connected to terminal 2.

The three phase voltages V_{L1}, V_{L2} and V_{L3} are connected to terminals 7, 8, 9 respectively. The earthed star point of the voltage transformer is connected to terminal 10.

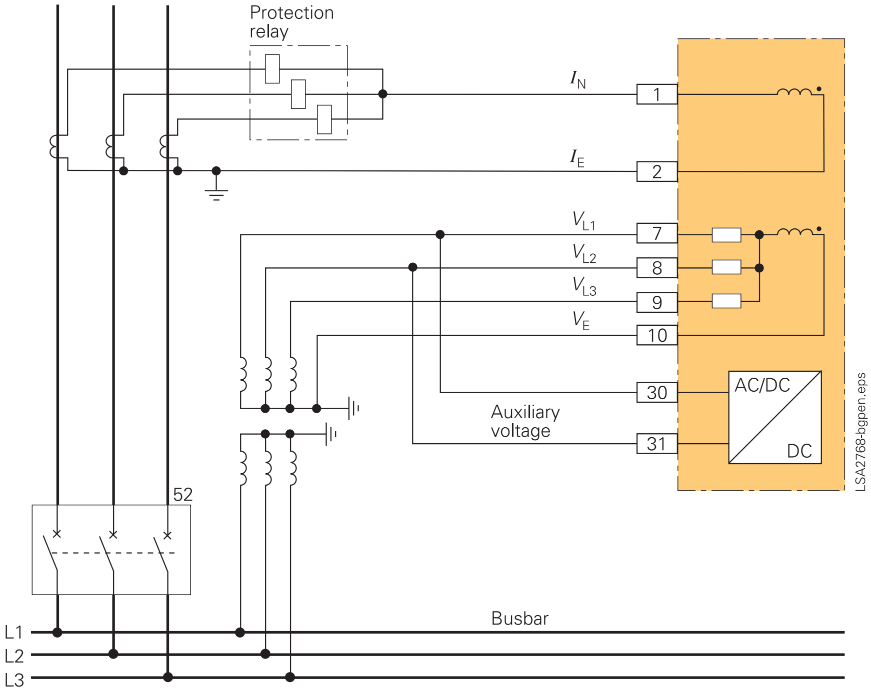


Fig. 10/44 Connection of transformers and auxiliary power supply for panel flush-mounting housing and panel surface-mounting housing (terminals on the side)

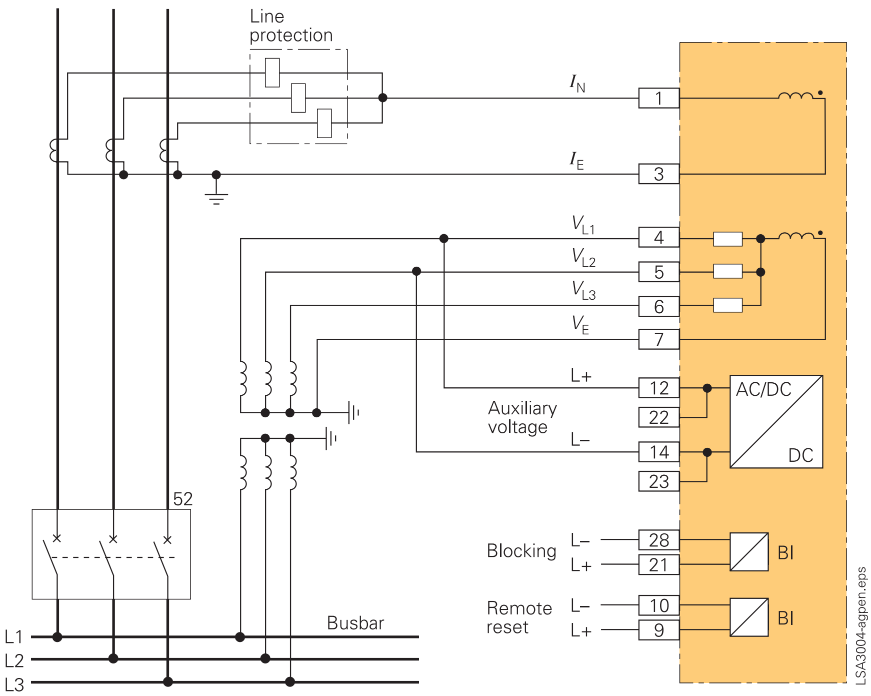


Fig. 10/45 Connection of transformers and auxiliary power supply for panel surface-mounting housing (terminals on the top/bottom)

10

Technical data

General unit data		
Measuring circuit		
Rated current I_0	1 or 5 A	
Input impedance Z at 50 Hz and I_N	< 0.05 Ω	
Rated voltage V_N	100/110 V AC	
Rated frequency f_N	50 Hz (16.7 Hz)	
Thermal rating		
- In voltage path, continuous	140 V AC	
- In current path, continuous	4 x I_N	
10 s	30 x I_N	
1 s (at 1 A)	100 x I_N	
1 s (at 5)	300 A	
Auxiliary voltage		
Rated auxiliary voltage V_{aux}	60 – 250 V DC and 100 – 230 V AC without switchover	
Power consumption at	Quiescent	Energized
60 V DC	3.1 W	4.5 W
110 V DC	3.0 W	4.5 W
220 V DC	3.6 W	4.6 W
250 V DC	3.7 W	4.8 W
100 V AC	2.9 VA	4.2 VA
110 V AC	3.0 VA	4.2 VA
230 V AC	4.6 VA	5.8 VA
Binary inputs		
Input voltage for blocking and remote reset input	24 - 250 V DC	
Pickup thresholds for		
– Blocking X30 pin 1-2, remote reset X31 pin 1-2	Approx. 19 V	
– Blocking X30 pin 2-3, remote reset X31 pin 2-3	Approx. 75 V	
Signaling relays		
Number of relays, forward or reverse direction	2 NO contacts	
Number of relays, continuous earth-fault signal	1 NO contact	
Number of relays, alarm	1 NC contact	
Switching capacity Make (all relays)	1000 W/VA	
Switching capacity Break (all relays)	30 W/VA	
Switching voltage	250 V AC/DC	
Permissible switching current		
Continuous	5 A	
0.5 s	30 A	
Unit design		
Housing, dimensions	SIPROTEC housing of 1/6 width Refer to part 16 for dimension drawings	
For flush mounting, terminals at the top/bottom	6 current / 25 voltage terminals	
For panel surface mounting, terminals on the side	6 current / 25 voltage terminals	
Weight	Approx. 4 kg	
Standards		
DIN VDE 0435, Part 303 and IEC 60255-5		

10

Selection and ordering data

Description	Order No.
7SN60 transient earth-fault protection relay	*7SN6000-□□A00*
In SIPROTEC housing 1/6 width Rated frequency 50 Hz	
Rated auxiliary voltage	
60 - 250 V DC and 100 - 230 V AC without switchover	*0*
24 - 48 V DC	*1*
For panel surface mounting with terminals on the side	*B*
For panel surface mounting with terminals at top/bottom part	*D*
For panel flush mounting or cubicle mounting	*E*

Connection diagram

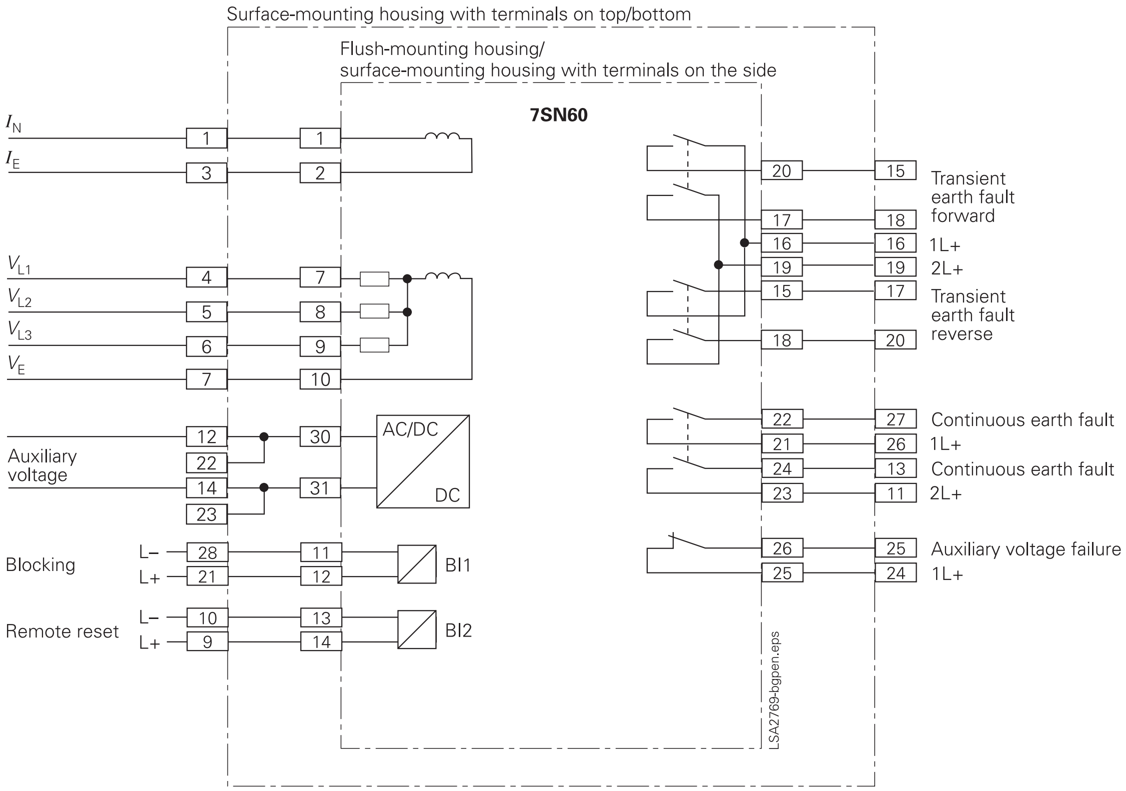


Fig. 10/46 Connection diagram

Generator Protection

Page

11

SIPROTEC 4 7UM61
Multifunction Generator and Motor Protection Relay

LSP2176-afpen.tif

Fig. 11/1 SIPROTEC 4 7UM61 multifunction generator and motor protection relay

Description

The SIPROTEC 4 7UM61 protection relays can do more than just protect. They also offer numerous additional functions. Be it earth faults, short-circuits, overloads, overvoltage, overfrequency or underfrequency, protection relays assure continued operation of power stations. The SIPROTEC 4 7UM61 protection relay is a compact unit which has been specially developed and designed for the protection of small and medium-sized generators. They integrate all the necessary protection functions and are particularly suited for the protection of :

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Diesel generator stations
- Gas-turbine power stations
- Industrial power stations
- Conventional steam power stations.

The device can also be used for protecting synchronous and asynchronous motors.

The integrated programmable logic functions (continuous function chart CFC) offer the user high flexibility so that adjustments can easily be made to the varying power station requirements, on the basis of special system conditions.

The flexible communication interfaces are open for modern communication architectures with the control system.

Function overview

Basic version

- Stator earth-fault protection
- Sensitive earth-fault protection
- Stator overload protection
- Overcurrent-time protection (either definite-time or inverse-time)
- Definite-time overcurrent-time protection, directional
- Undervoltage and overvoltage protection
- Underfrequency and overfrequency protection
- Reverse power protection
- Overexcitation protection
- External trip coupling

Standard version

Scope of basic version plus:

- Forward-power protection
- Underexcitation protection
- Negative-sequence protection
- Breaker failure protection

Full version

Scope of standard version plus:

- Inadverdent energization protection
- 100 % - stator earth-fault protection with 3rd harmonic
- Impedance protection

Asynchronous motor

Scope of standard version plus

- Motor starting time supervision
- Restart inhibit (without underexcitation protection)

Monitoring functions

- Trip circuit supervision
- Fuse failure monitor
- Operational measured values $V, I, f, \ldots$
- Every metering value W_p, W_q
- Time metering of operation hours
- Self-supervision of relay
- 8 oscillographic fault records

Communication interfaces

- System interface
  - IEC 60870-5-103 protocol
  - PROFIBUS-DP
  - MODBUS RTU
  - DNP 3.0

11

Application

The 7UM6 protection relays of the SIPROTEC 4 family are compact multifunction units which have been developed for small to medium-sized power generation plants. They incorporate all the necessary protective functions and are especially suitable for the protection of:

- Hydro and pumped-storage generators
- Co-generation stations
- Private power stations using regenerative energy sources such as wind or biogases
- Power generation with diesel generators
- Gas turbine power stations
- Industrial power stations
- Conventional steam power stations.

They can also be employed for protection of motors and transformers.

The numerous other additional functions assist the user in ensuring cost-effective system management and reliable power supply. Measured values display current operating conditions. Stored status indications and fault recording provide assistance in fault diagnosis not only in the event of a disturbance in generator operation.

Combination of the units makes it possible to implement effective redundancy concepts.

Protection functions

Numerous protection functions are necessary for reliable protection of electrical machines. Their extent and combination are determined by a variety of factors, such as machine size, mode of operation, plant configuration, availability requirements, experience and design philosophy.

This results in multifunctionality, which is implemented in outstanding fashion by numerical technology.

In order to satisfy differing requirements, the combination of functions is scalable (see Table 11/1). Selection is facilitated by division into groups.

Protection functions	Abbreviation	ANSI No.	Generator Basic	Generator Standard	Generator Full	Motor async.
Stator earth-fault protection non-directional, directional	$V_0>$, $3I_0>$ $\angle(V_0, 3I_0)$	59N, 64G 67G	X	X	X	X
Sensitive earth-fault protection (also rotor earth-fault protection)	$I_{EE}>$	50/51GN (64R)	X	X	X	X
Stator overload protection	I^2t	49	X	X	X	X
Definite-time overcurrent protection with undervoltage seal-in	$I> +V<$	51	X	X	X	X
Definite-time overcurrent protection, directional	$I>>$, Direc.	50/51/67	X	X	X	X
Inverse-time overcurrent protection	$t = f(I)+V<$	51V	X	X	X	X
Overvoltage protection	$V>$	59	X	X	X	X
Undervoltage protection	$V<$	27	X	X	X	X
Frequency protection	$f<$, $f>$	81	X	X	X	X
Reverse-power protection	$-P$	32R	X	X	X	X
Overexcitation protection (Volt/Hertz)	V/f	24	X	X	X	
Fuse failure monitor	V_2/V_1, I_1/I_2	60FL	X	X	X	X
External trip coupling (7UM611/612)	Incoup.		2/4	2/4	2/4	2/4
Trip circuit supervision (7UM612)	T.C.S.	74TC	X	X	X	X
Forward-power protection	$P>$, $P<$	32F		X	X	X
Underexcitation protection	1/xd	40		X	X	
Negative-sequence protection	$I_2>$, $t = f(I_2)$	46		X	X	X
Breaker failure protection	$I_{min}>$	50BF		X	X	X
Inadvertent energization protection	$I>$, $V<$	50/27			X	
100 %-stator-earth-fault protection with 3rd harmonics	$V_{0(3^{rd}\ harm)}$	59TN 27TN (3rd h.)			X	
Impedance protection with ($I>+V<$)-pickup	$Z<$	21			X	
Motor starting time supervision	I_{an}^2t	48			X	X
Restart inhibit for motors	I^2t	49 Rotor			X	X
External temperature monitoring through serial interface	ϑ (Thermo-box)	38	X	X	X	X
Rate-of-frequency-change protection[1)]	$df/dt >$	81R	X	X	X	X
Vector jump supervision (voltage)[1)]	$\Delta\varphi >$		X	X	X	X

Table 11/1 Scope of functions of the 7UM61

Generator Basic

One application is concentrated on small generators or as backup protection for larger generators. The function mix is also an effective addition to transformer differential protection with parallel-connected transformers. The functions are also suitable for system disconnection.

Generator Standard

This function mix is recommended for generator outputs exceeding 1 MVA.
It is also suitable for protection of synchronous motors.
Another application is as backup protection for the larger block units.

Generator Full

Here, all protection functions are available and are recommended from generator outputs exceeding 5 MVA. Backup protection for the larger block units is also a recommended application.

Asynchronous motor

This protection function mix is recommended for motors up to 1 - 2 MW.
It offers a wide frequency operating range from 11 Hz to 69 Hz. When an infeed is switched, the protection adapts to the changed voltage and frequency.

1) Available as an option (please refer to Order No., position 15).

Application

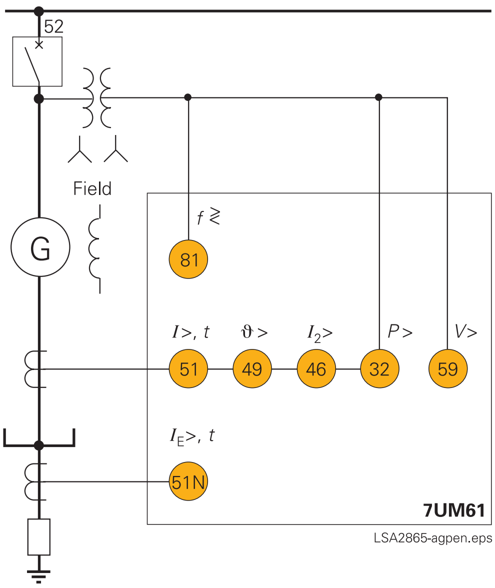


Fig. 11/2

Construction

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control. Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays were a major design aim. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

The 7UM611 is configured in 1/3 19 inch, and the 7UM612 in 1/2 19 inch width. This means that the units of previous models can be replaced. The height throughout all housing width increments is 243 mm.

All wires are connected directly or by means of ring-type cable lugs.

Alternatively, versions with plug-in terminals are also available. These permit the use of prefabricated cable harnesses.

In the case of panel surface mounting, the connecting terminals are in the form of screw-type terminals at top and bottom. The communication interfaces are also arranged on the same sides.

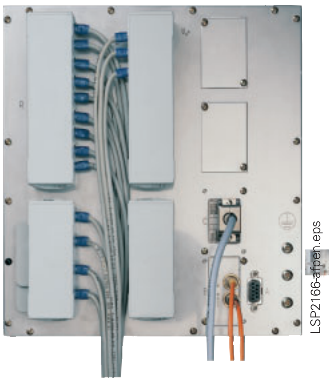


Fig. 11/3
Rear view with wiring terminal safety cover and serial interface

Protection functions

Definite-time overcurrent protection $I>, I>>$ (ANSI 50, 51, 67)

This protection function comprises the short-circuit protection for the generator and also the backup protection for upstream devices such as transformers or power system protection.

An undervoltage stage at $I>$ maintains the pickup when, during the fault, the current falls below the threshold. In the event of a voltage drop on the generator terminals, the static excitation system can no longer be sufficiently supplied. This is one reason for the decrease of the short-circuit current.

The $I>>$ stage can be implemented as high-set instantaneous trip stage. With the integrated directional function it can be applied for generators without star point CT (see Figure 11/4).

Inverse-time overcurrent protection (ANSI 51V)

This function also comprises short-circuit and backup protection and is used for power system protection with current-dependent protection devices.

IEC and ANSI characteristics can be selected (Table 11/2).

The current function can be controlled by evaluating the generator terminal voltage.

The "controlled" version releases the sensitive set current stage.

With the "restraint" version, the pickup value of the current is lowered linearly with decreasing voltage.

The fuse failure monitor prevents unwanted operation.

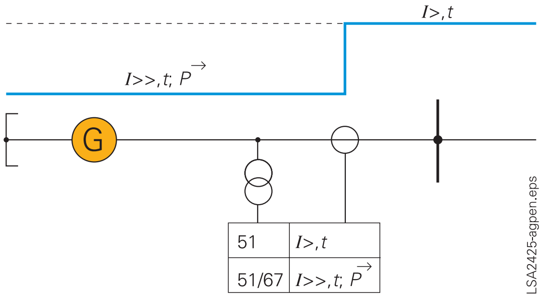


Fig. 11/4
Protection with current transformer on terminal side

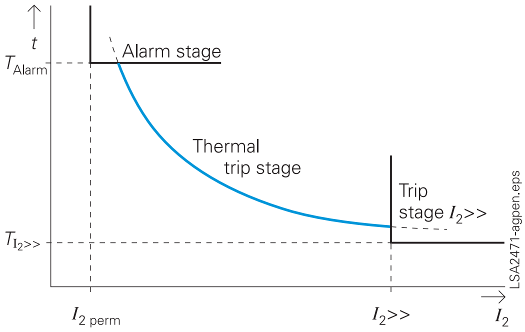


Fig. 11/5
Characteristic of negative-sequence protection

Stator overload protection (ANSI 49)

The task of the overload protection is to protect the stator windings of generators and motors from high, continuous overload currents. All load variations are evaluated by the mathematical model used. The thermal effect of the r.m.s. current value forms the basis of the calculation. This conforms to IEC 60255-8. In dependency of the current the cooling time constant is automatically extended. If the ambient temperature or the temperature of the coolant are injected via PROFIBUS-DP, the model automatically adapts to the ambient conditions; otherwise a constant ambient temperature is assumed.

Negative-sequence protection (ANSI 46)

Asymmetrical current loads in the three phases of a generator cause a temperature rise in the rotor because of the negative sequence field produced.

This protection detects an asymmetrical load in three-phase generators. It functions on the basis of symmetrical components and evaluates the negative sequence of the phase currents. The thermal processes are taken into account in the algorithm and form the inverse characteristic. In addition, the negative sequence is evaluated by an independent stage (alarm and trip) which is supplemented by a time-delay element (see Figure 11/5).

Available inverse-time characteristic

Characteristics	ANSI / IEEE	IEC 60255-3
Inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	

Table 11/2

11

Protection functions

Underexcitation protection (ANSI 40) (Loss-of-field protection)

Derived from the generator terminal voltage and current, the complex admittance is calculated and corresponds to the generator diagram scaled in per unit. This protection prevents damage due to loss of synchronism resulting from underexcitation. The protection function provides three characteristics for monitoring static and dynamic stability. In the event of exciter failure, fast response of the protection can be ensured via binary input. This input releases a timer with a short time delay.

The straight-line characteristics allow the protection of the generator diagram to be optimally adapted (see Fig. 11/6). The per-unit-presentation of the diagram allows the setting values to be directly read out.

The positive-sequence systems of current and voltage are used to calculate the admittance. This ensures that the protection always operates correctly even with asymmetrical network conditions.

If the voltage deviates from the rated voltage, the admittance calculation has the advantage that the characteristics move in the same direction as the generator diagram.

Reverse-power protection (ANSI 32R)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails because then the drive power is taken from the network. This function can be used for operational shutdown (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical network faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (±) of the active power can be reversed via parameters.

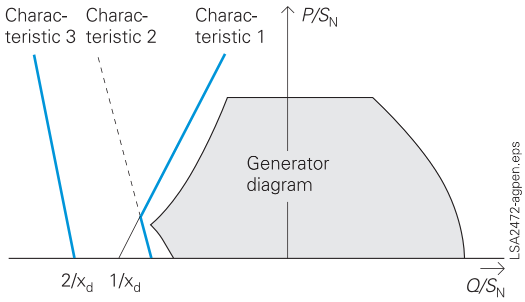


Fig. 11/6
Characteristic of underexcitation protection

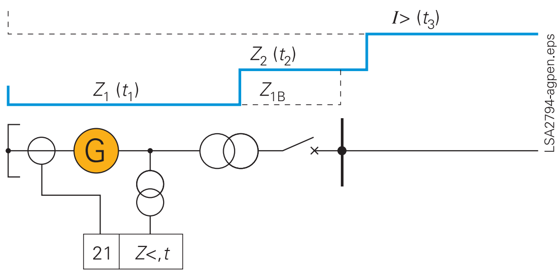


Fig. 11/7
Grading of impedance protection

Forward-power protection (ANSI 32F)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors threshold beyond one limit value while another stage monitors threshold below another limit value. The power is calculated using the positive-sequence component of current and voltage.

Impedance protection (ANSI 21)

This fast short-circuit protection protects the generator, the generator transformer and is a backup protection for the power system. This protection has two settable impedance stages; in addition, the first stage can be switched over via binary input. With the circuit-breaker in "open" position (see Fig. 11/7) the impedance measuring range can be extended. The overcurrent pickup element with undervoltage seal-in ensures a reliable pickup and the loop selection logic a reliable detection of the faulty loop. With this logic it is possible to perform a correct measurement via the unit transformer.

Undervoltage protection (ANSI 27)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.

The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-earth voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by earth-faults. This function is implemented in two stages.

Protection functions

Frequency protection (ANSI 81)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency. It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as underfrequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

Overexcitation protection Volt/Hertz (ANSI 24)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to V/f) in generators or transformers, which leads to thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via seven points derived from the manufacturer data.

In addition, a definite-time alarm stage and an instantaneous stage can be used.

For calculation of the V/f ratio, frequency and also the highest of the three line-to-line voltages are used. The frequency range that can be monitored comprises 11 to 69 Hz.

Stator earth-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)

Earth faults manifest themselves in generators that are operated in isolation by the occurrence of a displacement voltage. In case of unit connections, the displacement voltage is an adequate, selective criterion for protection.

For the selective earth-fault detection, the direction of the flowing earth current has to be evaluated too, if there is a direct connection between generator and busbar.

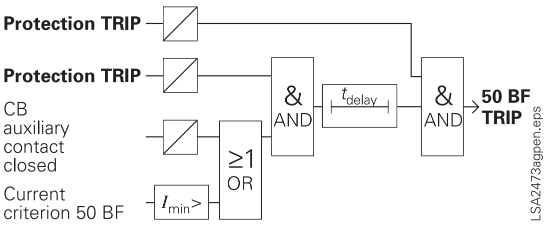


Fig. 11/8
Logic diagram of breaker failure protection

The protection relay measures the displacement voltage at a VT located at the transformer star point or at the broken delta-winding of a VT. As an option, it is also possible to calculate the zero-sequence voltage from the phase-to-earth voltages. Depending on the load resistor selection, 90 to 95 % of the stator winding of a generator can be protected.

A sensitive current input is available for earth-current measurement. This input should be connected to a core-balance current transformer. The fault direction is deduced from the displacement voltage and earth current. The directional characteristic (straight line) can be easily adapted to the system conditions. Effective protection for direct connection of a generator to a busbar can therefore be established. During start-up, it is possible to switch over from the directional to the displacement voltage measurement via an externally injected signal.

Depending on the protection setting, various earth-fault protection concepts can be implemented with this function (see Figs. 11/17 to 11/21).

Sensitive earth-fault protection (ANSI 50/51GN, 64R)

The sensitive earth-current input can also be used as separate earth-fault protection. It is of two-stage form. Secondary earth currents of 2 mA or higher can be reliably handled.

Alternatively, this input is also suitable as rotor earth-fault protection. A voltage with rated frequency (50 or 60 Hz) is connected in the rotor circuit via the interface unit 7XR61. If a higher earth current is flowing, a rotor earth fault has occurred. Measuring-circuit monitoring is provided for this application (see Figure 11/20).

100 % stator earth-fault protection with 3rd harmonic (ANSI 59TN, 27TN (3rdH.))

Owing to the design, the generator produces a 3rd harmonic that forms a zero system. It is verifiable by the protection on a broken delta winding or on the neutral transformer. The magnitude of the voltage amplitude depends on the generator and its operation.

In the event of an earth fault in the vicinity of the neutral point, there is a voltage displacement in the 3rd harmonic (dropping in the neutral point and rising at the terminals).

Depending on the connection, the protection must be set in either undervoltage or overvoltage form. It can also be delayed. So as to avoid overfunction, the active power and the positive-sequence voltage act as enabling criteria.

The final protection setting can be made only by way of a primary test with the generator.

Breaker failure protection (ANSI 50BF)

In the event of scheduled downtimes or a fault in the generator, the generator can remain on line if the circuit-breaker is defective and could suffer substantial damage.

Breaker failure protection evaluates a minimum current and the circuit-breaker auxiliary contact. It can be started by internal protective tripping or externally via binary input. Two-channel activation avoids overfunction (see Figure 11/8).

Protection functions

Inadvertent energization protection (ANSI 50, 27)

This protection has the function of limiting the damage of the generator in the event of an unintentional switch-on of the circuit-breaker, whether the generator is standing still or rotating without being excited or synchronized. If the power system voltage is connected, the generator starts as an asynchronous machine with a large slip and this leads to excessively high currents in the rotor.

A logic circuit consisting of sensitive current measurement for each phase, measured value detector, time control and blocking as of a minimum voltage, leads to an instantaneous trip command. If the fuse failure monitor responds, this function is ineffective.

Starting time supervision (motor protection only) (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups, which might occur as a result of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked.

The tripping time is dependent on the square of the start-up current and the set start-up time (Inverse Characteristic). It adapts itself to the start-up with reduced voltage. The tripping time is determined in accordance with the following formula:

$$t_{\text{Trip}} = \left(\frac{I_{\text{start}}}{I_{\text{rms}}}\right)^2 \cdot t_{\text{start max}}$$

t_{Trip}	Tripping time
I_{start}	Permissible start-up current
$t_{\text{start max}}$	Permissible start-up time
I_{rms}	Measured r.m.s. current value

Calculation is not started until the current I_{rms} is higher than an adjustable response value
(e.g. 2 $I_{\text{N, MOTOR}}$).

If the permissible locked-rotor time is less than the permissible start-up time (motors with a thermally critical rotor), a binary signal is set to detect a locked rotor by means of a tachometer generator. This binary signal releases the set locked-rotor time, and tripping occurs after it has elapsed.

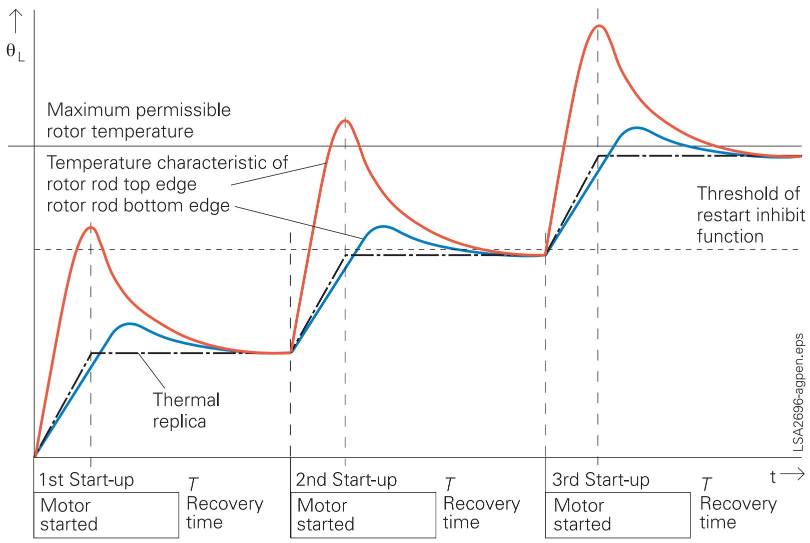


Fig. 11/9 Temperature characteristic at rotor and thermal replica of the rotor (multiple start-ups)

Restart inhibit for motors (ANSI 66, 49Rotor)

When cold or at operating temperature, motors may only be connected a certain number of times in succession. The start-up current causes heat development in the rotor which is monitored by the restart inhibit function.

Contrary to classical counting methods, in the restart inhibit function the heat and cooling phenomena in the rotor are simulated by a thermal replica. The rotor temperature is determined on the basis of the stator currents. Restart inhibit permits restart of the motor only if the rotor has enough thermal reserve for a completely new start. Fig. 11/9 illustrates the thermal profile for a permissible triple start out of the cold state. If the thermal reserve is too low, the restart inhibit function issues a blocking signal with which the motor starting circuit can be blocked. The blockage is cancelled again after cooling down and the thermal value has dropped below the pickup threshold.

As the fan provides no forced cooling when the motor is off, it cools down more slowly. Depending on the operating state, the protection function controls the cooling time constant. A value below a minimum current is an effective changeover criterion.

System disconnection

Take the case of in-plant generators feeding directly into a system. The incoming line is generally the legal entity boundary between the system owner and the in-plant generator. If the incoming line fails as the result of auto-reclosure, for instance, a voltage or frequency deviation may occur depending on the power balance at the feeding generator. Asynchronous conditions may arise in the event of connection, which may lead to damage on the generator or the gearing between the generator and the turbine. Besides the classic criteria such as voltage and frequency, the following two criteria are also applied (vector jump, rate-of-frequency-change protection).

Rate-of-frequency-change protection (ANSI 81)

The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed so that it reacts to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

Protection functions

Vector jump

Monitoring the phase angle in the voltage is a criterion for identifying an interrupted infeed. If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

External trip coupling

For recording and processing of external trip information, there are 2 (for 7UM611) or 4 (for 7UM612) binary inputs. They are provided for information from the Buchholz relay or generator-specific commands and act like a protective function. Each input initiates a fault event and can be individually delayed by a timer.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Phase rotation reversal

If the relay is used in a pumped-storage power plant, matching to the prevailing rotary field is possible via a binary input (generator/motor operation via phase rotation reversal).

2 pre-definable parameter groups

In the protection, the setting values can be stored in two data sets. In addition to the standard parameter group, the second group is provided for certain operating conditions (pumped-storage power stations). It can be activated via binary input, local control or DIGSI 4.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Fuse failure and other monitoring

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions.

The positive and negative-sequence system (voltage and current) are evaluated.

Filter time

All binary inputs can be subjected to a filter time (indication suppression).

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program during commissioning is particularly advantageous.

Rear-mounted interfaces

Two communication modules on the rear of the unit incorporate optional equipment complements and permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces (electrical or optical) and protocols (IEC 60870, PROFIBUS, DIGSI).

The interfaces make provision for the following applications:

Service interface

In the RS485 version, several protection units can be centrally operated with DIGSI 4. By using a modem, remote control is possible. This provides advantages in fault clearance, in particular in unmanned substations.

System interface

This is used to communicate with a control or protection and control system and supports, depending on the module connected, a variety of communication protocols and interface designs.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for communication with protection relays.

IEC 60870-5-103 is supported by a number of protection unit manufacturers and is used worldwide.

The generator protection functions are stored in the manufacturer-specific, published part of the protocol.

PROFIBUS-DP

PROFIBUS is an internationally standardized communication protocol (EN 50170). PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world.

With the PROFIBUS-DP, the protection can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and information from or to the logic (CFC).

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic interference influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any faults.

- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

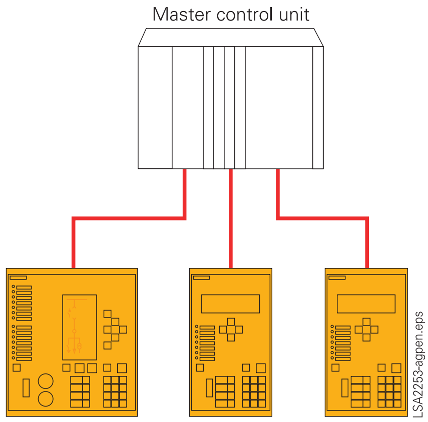


Fig. 11/10
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

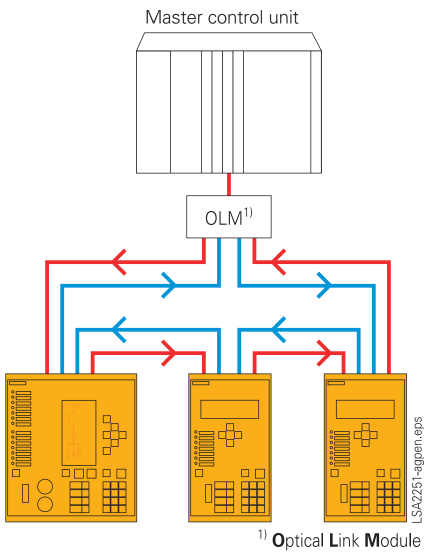


Fig. 11/11
PROFIBUS: Optical double ring circuit

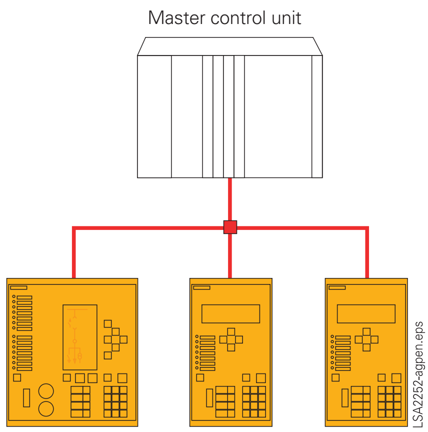


Fig. 11/12
PROFIBUS: RS485 copper conductors

11

Communication

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems.

Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the protection unit.

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

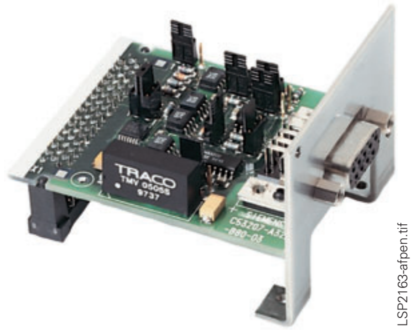


Fig. 11/13
RS232/RS485
Electrical communication module

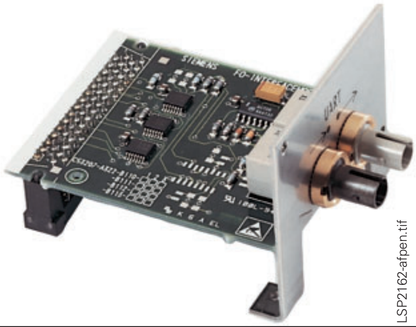


Fig. 11/14
Fiber-optic communication module

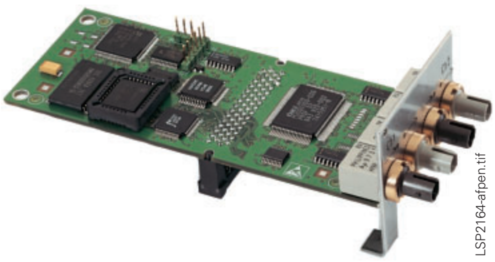


Fig. 11/15
Communication module, optical, double-ring

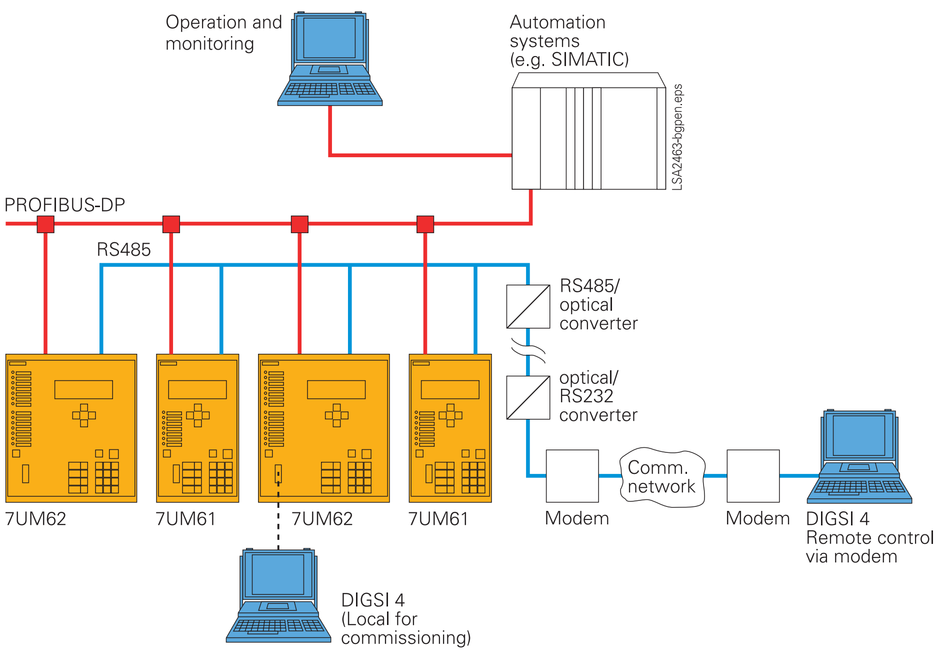


Fig. 11/16
System solution: Communication

Typical connections

Direct generator - busbar connection

Fig. 11/17 illustrates the recommended standard connection if several generators supply one busbar. Phase-to-earth faults are disconnected by employing the directional earth-fault criterion. The earth-fault current is driven through the cables of the system. If this is not sufficient, an earthing transformer connected to the busbar supplies the necessary current (maximum approximately 10 A) and permits a protection range of up to 90 %. The earth-fault current should be detected by means of core-balance current transformers in order to achieve the necessary sensitivity. The displacement voltage can be used as earth-fault criterion during starting operations until synchronization is achieved.

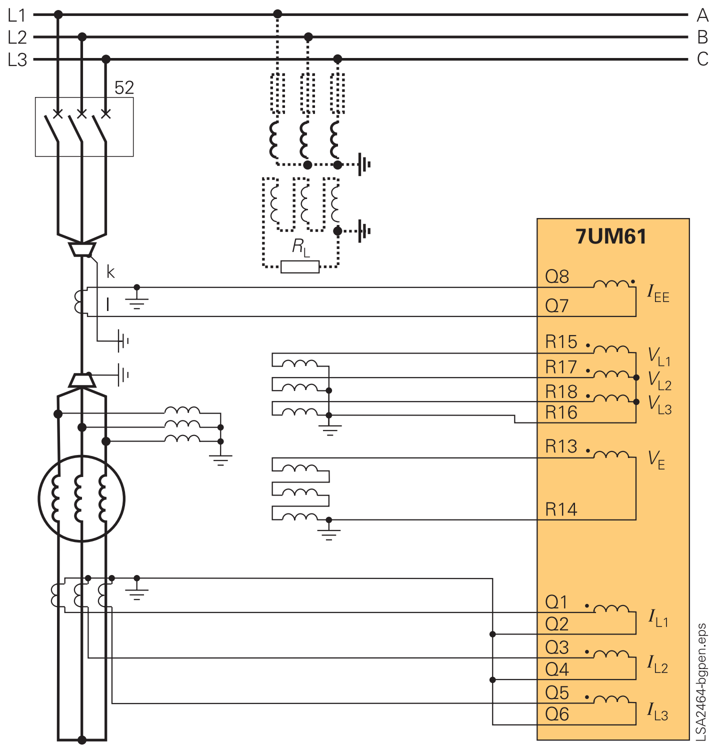


Fig. 11/17

Direct generator - busbar connection with low-resistance earthing

If the generator neutral point has low-resistance earthing, the connection illustrated in Fig. 11/18 is recommended. In the case of several generators, the resistance must be connected to only one generator, in order to prevent circulating currents (3rd harmonic).

For selective earth-fault detection, the earth-current input should be looped into the common return conductor of the two current transformer sets (differential connection). The current transformers must be earthed at only one point. The displacement voltage V_E is utilized as an additional enabling criterion.

Balanced current transformers are desirable with this form of connection. In the case of higher generator power (for example, I_N approximately 2000 A), current transformers with a secondary rated current of 5 A are recommended.

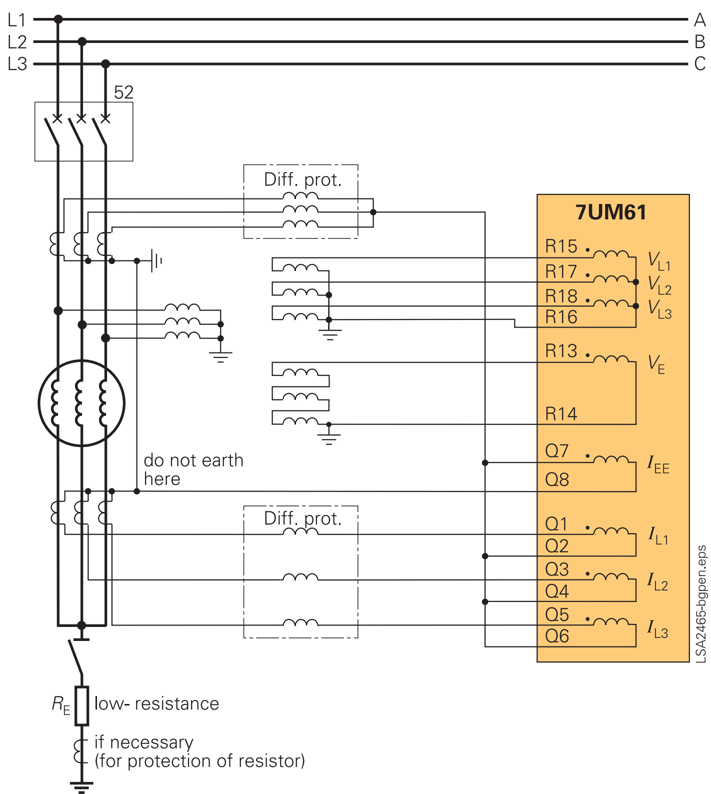


Fig. 11/18

Typical connections

Direct generator - busbar connection with high-resistance generator neutral earthing

With this system configuration, selective earth-fault detection is implemented on the basis of the lower fault currents through the differential connection of core-balance current transformers (see Figure 11/19). Secondary-side earthing must be effected at only one core-balance current transformer. The displacement voltage is to be utilized additionally as enable criterion.

The load resistor takes the form either of primary or of secondary resistor with neutral transformer. In the case of several generators connected to the busbar, again only one generator will be earthed via the resistor.

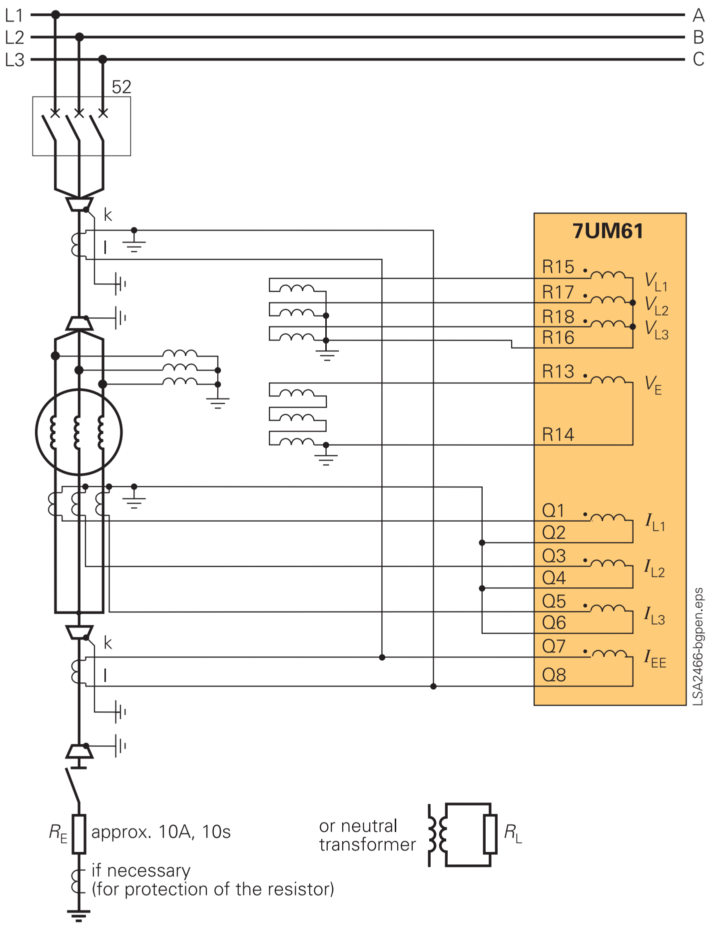


Fig. 11/19

Unit connection with isolated star point

This configuration of unit connection is a variant to be recommended (see Figure 11/20). Earth-fault detection is effected by means of the displacement voltage. In order to prevent unwanted operation in the event of earth faults in the system, a load resistor must be provided at the broken delta winding. Depending on the plant (or substation), a voltage transformer with a high power (VA) may in fact be sufficient. If not, an earthing transformer should be employed. The available measuring winding can be used for the purpose of voltage measurement.

Rotor earth-fault protection can be implemented with the unassigned earth-fault current input. The 7XR61 coupling unit must be used for this purpose.

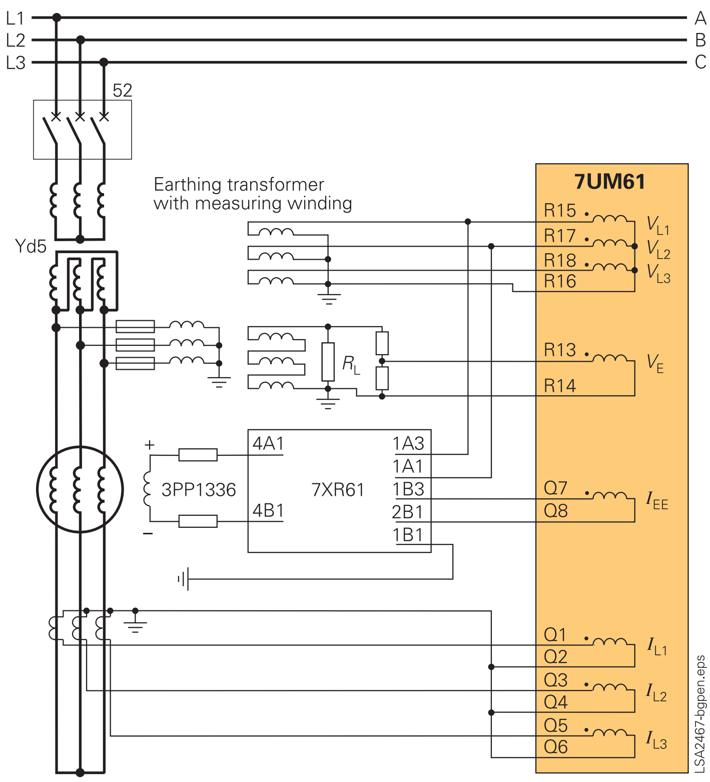


Fig. 11/20

Typical connections

Unit connection with neutral transformer

With this system configuration, disturbance voltage reduction and damping in the event of earth faults in the generator area are effected by a load resistor connected to generator neutral point. The maximum earth-fault current is limited to approximately 10 A. Configuration can take the form of a primary or secondary resistor with neutral transformer. In order to avoid low secondary resistance, the transformation ratio of the neutral transformer should be low. The higher secondary voltage can be reduced by means of a voltage divider.

Electrically, the circuit is identical to the configuration in Figure 11/20.

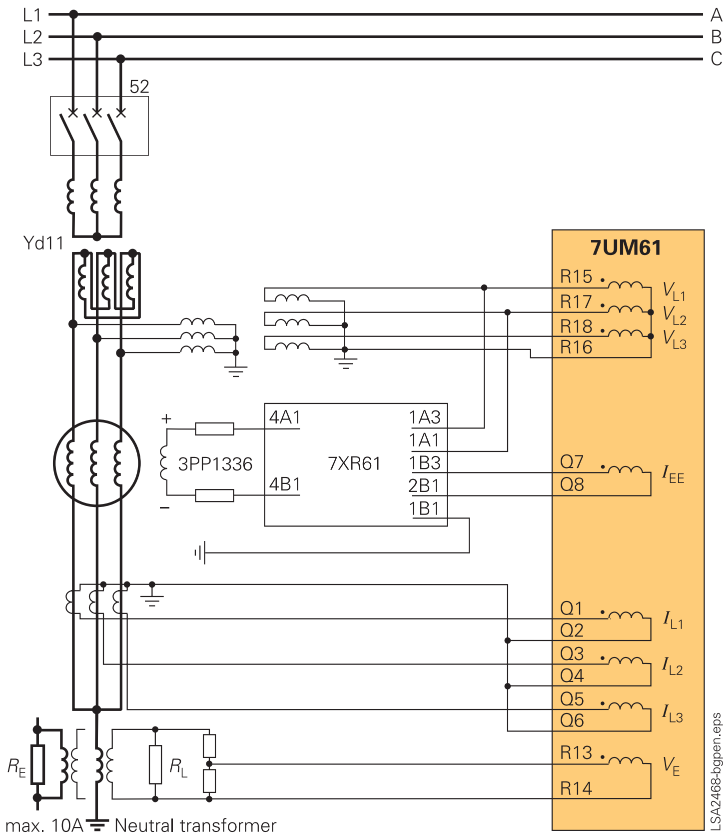


Fig. 11/21

Connection with low-voltage generators

As is generally known, the low-voltage system is solidly earthed, so that the generator neutral point is connected to earth (see Figure 11/22). With this configuration, there is the risk that, as a result of the 3rd harmonics forming a zero phase-sequence system, circulating currents will flow via the N-conductor. This must be limited by the generator or system configuration (reactor).

Otherwise, connection corresponds to the customary standard. In the case of residual current transformer design, it has to be ensured that the thermal current limit (1 s) of the I_{EE} input is restricted to 300 A.

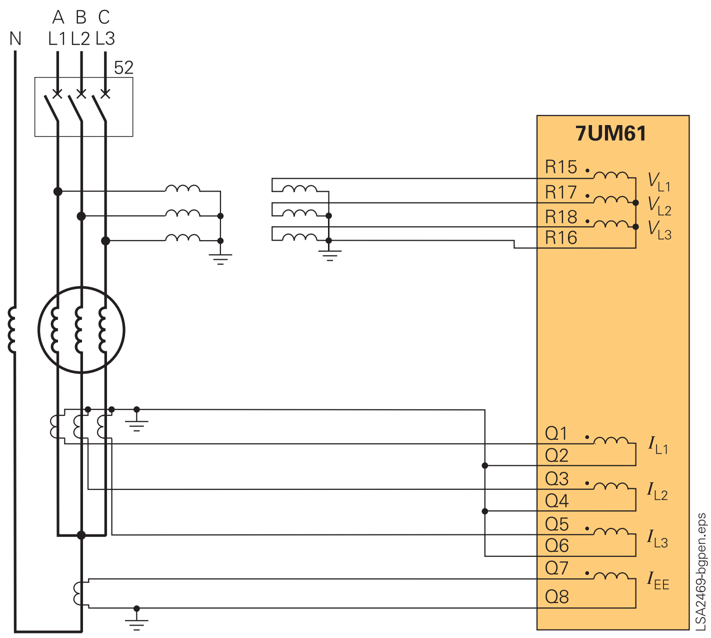


Fig. 11/22

11

Typical connections

Connection of an asynchronous motor

The figure shows the standard connection of motors of medium capacity (500 kW to <(1-2) MW). In addition to the short-circuit protection, an earth-fault protection (V_E; I_E inputs) is available.

As the busbar voltage is being monitored, starting of the motor is prevented if the voltage is too low or - in case of failure of infeed - the motor circuit-breaker is opened. Here, the wide range of frequency is advantangeous. For the detection of temperatures, 2 thermo-boxes (temperature monitoring boxes) can be connected via a serial interface.

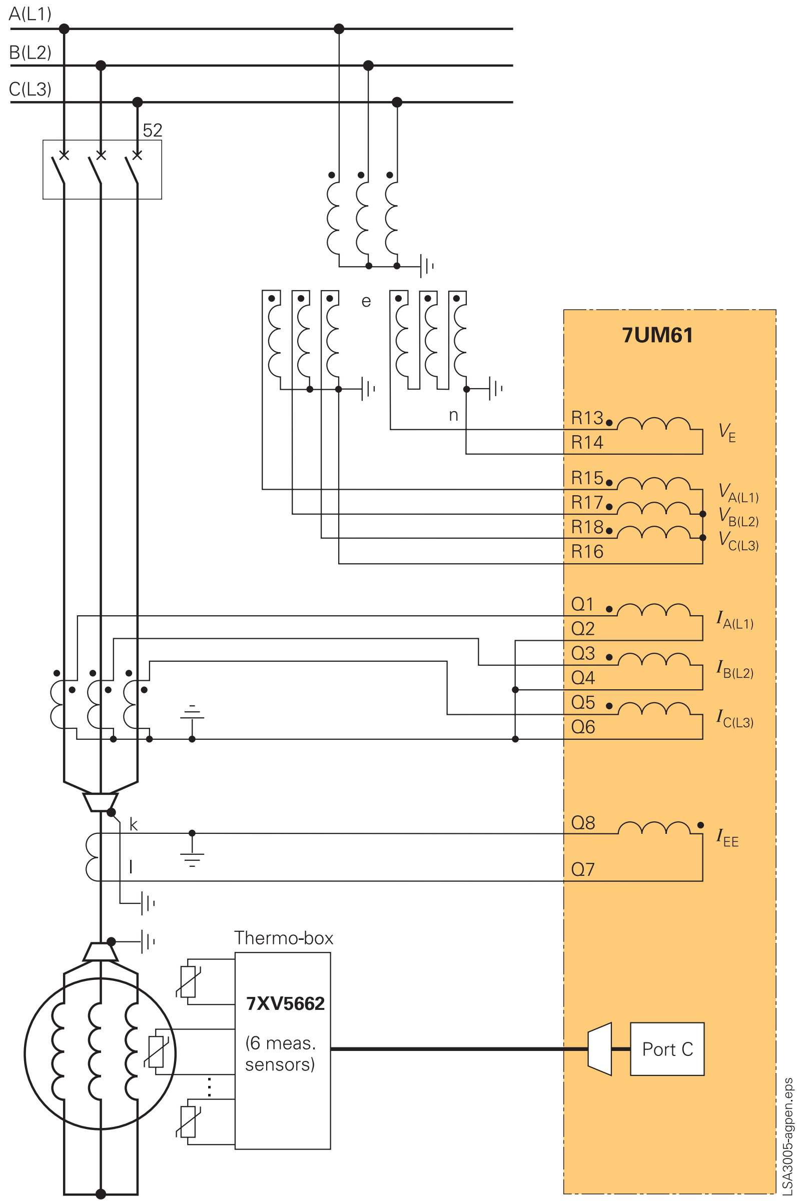


Fig. 11/23

Typical connections

Voltage transformer in open delta connection (V-connection)

Protection can also be implemented on voltage transformers in open delta connection. Figure 11/24 shows the connection involved. If necessary, the operational measured values for the phase-to-earth voltages can be slightly asymmetrical. If this is disturbing, the neutral point (R16) can be connected to earth via a capacitor.

In the case of open delta connection, it is not possible to calculate the displacement voltage from the secondary voltages. It must be passed to the protection relay along a different path (for example, voltage transformer at the generator neutral point or from the earthing transformer).

Connection with two current transformers

This configuration is to be found in older systems with insulated or high-resistance star point. This connection is illustrated in Fig. 11/25. In the protection unit, the secondary currents are represented correctly and, in addition, the positive and the negative-sequence system are correctly calculated. Limits of application occur in the case of low-resistance and solid earthing.

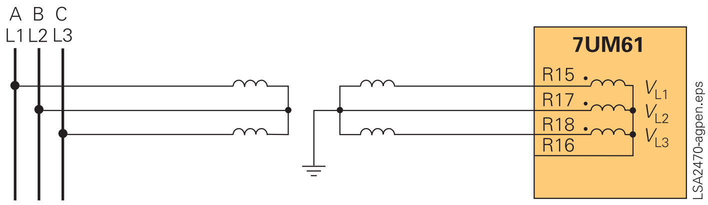


Fig. 11/24

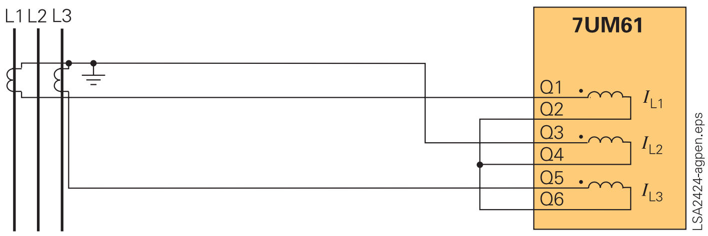


Fig. 11/25

Technical data

Hardware

Analog inputs

Rated frequency	50 or 60 Hz
Rated current I_N	1 or 5 A
Earth current, sensitive I_{Emax}	1.6 A
Rated voltage V_N	100 to 125 V
Power consumption	
With I_N = 1 A	Approx. 0.05 VA
With I_N = 5 A	Approx. 0.3 VA
For sensitive earth current	Approx. 0.05 VA
Voltage inputs (with 100 V)	Approx. 0.3 VA
Capability in CT circuits	
Thermal (r.m.s. values)	100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous
Dynamic (peak)	250 I_N (one half cycle)
Earth current, sensitive	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (peak)	750 A (one half cycle)
Capability in voltage paths	230 V continuous

Auxiliary voltage

Rated auxiliary voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V/230 V AC with 50/60 Hz
Permitted tolerance	–20 to +20 %
Superimposed (peak-to-peak)	≤ 15 %
Power consumption	
During normal operation	
7UM611	Approx. 4 W
7UM612	Approx. 4.5 W
During pickup with all inputs and outputs activated	
7UM611	Approx. 9.5 W
7UM612	Approx. 12.5 W
Bridging time during auxiliary voltage failure	
at V_{aux} = 48 V and V_{aux} ≥ 110 V	≥ 50 ms
at V_{aux} = 24 V and V_{aux} = 60 V	≥ 20 ms

Binary inputs

Number	
7UM611	7
7UM612	15
3 pickup thresholds Range is selectable with jumpers	10 to 19 V DC or 44 to 88 V DC 88 to 176 V DC[1)]
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA

1) Not valid for the CPU board.

Output relays

Number	
7UM611	12 (1 NO, 1 optional as NC, via jumper)
7UM612	20 (1 NO, 2 optional as NC, via jumper)
Switching capacity	
Make	1000 W / VA
Break	30 VA
Break (for resistive load)	40 W
Break (for L/R ≤ 50 ms)	25 VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds

LEDs

Number	
RUN (green)	1
ERROR (red)	1
Assignable LED (red)	
7UM611	7
7UM612	14

Unit design

7XP20 housing	For dimensions see dimension drawings, part 16
Degree of protection acc. to EN 60529	
For surface-mounting housing	IP 51
For flush-mounting housing	
Front	IP 51
Rear	IP 50
For the terminals	IP 2x with terminal cover put on
Weight	
Flush mounting housing	
7UM611 (1/3 x 19″)	Approx. 5.5 kg
7UM612 (1/2 x 19″)	Approx. 7 kg
Surface mounting housing	
7UM611 (1/3 x 19″)	Approx. 7.5 kg
7UM612 (1/2 x 19″)	Approx. 12 kg

Technical data

Serial interfaces	
Operating interface for DIGSI 4	
Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector
Baud rate	4800 to 115200 baud
Time synchronization IRIG-B / DCF 77 signal (Format IRIG-B000)	
Connection	9-pin subminiature connector, terminal with surface-mounting housing
Voltage levels	Selectable 5 V or 12 V or 24 V
Service/modem interface for DIGSI 4/modem/service	
Isolated RS232/RS485 Test voltage Distance for RS232 Distance for RS485	9-pin subminiature connector 500 V / 50 Hz Max. 15 m Max. 1000 m
Fiber-optic cable Optical wavelength Permissible path attenuation Bridgeable distance	Integrated ST-connector λ = 820 nm Max. 8 dB for glass-fiber 62.5/125 µm Max. 1.5 km
System interface IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU	
Isolated RS232/RS485 Baud rate Test voltage Distance for RS232 Distance for RS485	9-pin subminiature connector 4800 to 115200 baud 500 V / 50 Hz Max. 15 m Max. 1000 m
PROFIBUS RS485 Test voltage Baud rate Distance	 500 V / 50 Hz Max. 12 Mbaud 1000 m at 93.75 kBaud; 100 m at 12 Mbaud
PROFIBUS fiber-optic Only for flush-mounting housing For surface-mounting housing Baud rate Optical wavelength Permissible path attenuation Distance	 ST connector Optical interface with OLM[1)] Max. 1.5 Mbaud λ = 820 nm Max. 8 dB for glass-fiber 62.5/125 µm 1.6 km (500 kB/s) 530 m (1500 kB/s)

1) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order code L0A (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435, part 303 For further standards see below.
Insulation tests	
Standards	IEC 60255-5
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs communication and time synchronization interfaces	2.5 kV (r.m.s.), 50/60 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	3.5 kV DC
Voltage test (100 % test) RS485/RS232 rear side communication interfaces and time synchronization interface	500 V (r.m.s. value), 50/60 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for noise immunity; *type test*	
Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and VDE 0435 part 303, class III	2.5 kV (peak value), 1 MHz; τ = 15 ms, 400 pulses per s; duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated, IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min

11

Technical data

EMC tests for noise immunity; type tests	
High-energy surge voltages (SURGE), IEC 61000-4-5 Installation, class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω, 9 µF Differential (transversal) mode: 1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	Common (longitudinal) mode: 2 kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; Duration 2 s; R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; Duration 2 s ; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω

EMC tests for interference emission; type tests	
Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks in both directions of the 3 axes

Technical data

Climatic stress tests	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	–25 °C to +85 °C / –13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	–20 °C to +70 °C / –4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6	–5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	–25 °C to +55 °C / –13 °F to +131 °F
– Limiting temperature during transport	–25 °C to +70 °C / –13 °F to +158 °F
Humidity	
Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation is not permitted

Functions	
General	
Frequency range	11 to 69 Hz
Definite-time overcurrent protection, directional *(ANSI 50, 51, 67)*	
Setting ranges	
Overcurrent $I>$, $I>>$	0.1 to 8 A (steps 0.01 A); 5 times at I_N = 5 A
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1 V)
Seal-in time of $V<$	0.1 to 60 s (steps 0.01 s)
Angle of the directional element (at $I>$)	– 90 ° to + 90 ° (steps 1 °)
Times	
Pickup time $I>$, $I>>$	
At 2 times of set value	Approx. 35 ms
At 10 times of set value	Approx. 25 ms
Drop-off time $I>$, $I>>$	Approx. 50 ms
Drop-off ratio	$I>$: 0.95; $I>>$: 0.9 to 0.99 (steps 0.01)
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Current pickup (starting) $I>$, $I>>$	1 % of set value or 10/50 mA
Undervoltage seal-in $V<$	1 % of set value or 0.5 V
Angle of the directional element	1 °
Time delays	1 % or 10 ms

Inverse-time overcurrent protection *(ANSI 51V)*	
Setting ranges	
Pickup overcurrent I_P	0.1 to 4 A (steps 0.01 A); 5 times at I_N = 5 A
Time multiplier IEC-characteristics T	0.05 to 3.2 s (steps 0.01 s) or indefinite
Time multiplier ANSI-characteristics D	0.5 to 15 (steps 0.01) or indefinite
Undervoltage release $V<$	10 to 125 V (steps 0.1 V)
Trip characteristics	
IEC	Normal inverse; very inverse; extremely inverse
ANSI	Inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Pickup threshold	Approx. 1.1 I_P
Drop-off threshold	Approx. 1.05 I_P for $I_P/I_N \geq 0.3$
Tolerances	
Pickup threshold I_P	1 % of set value 10/50 mA
Pickup threshold $V<$	1 % of set value or 0.5 V
Time for $2 \leq I/I_P \leq 20$	5 % of nominal value + 1 % current tolerance or 40 ms
Stator overload protection, thermal *(ANSI 49)*	
Setting ranges	
Factor k according to IEC 60255-8	0.5 to 2.5 (steps 0.01)
Time constant	30 to 32000 s (steps 1 s)
Time delay factor at standstill	1 to 10 (steps 0.01)
Alarm overtemperature $\Theta_{Alarm}/\Theta_{Trip}$	70 to 100 % related to the trip temperature (steps 1 %)
Overcurrent alarm stage I_{Alarm}	0.1 to 4 A (steps 0.01 A); 5 times at I_N = 5 A
Temperature at I_N	40 to 200 °C (steps 1 °C) or 104 to 392 °F (steps 1 °F)
Scaling temperature of cooling medium	40 to 300 °C (steps 1 °C) or 104 to 572 °F (steps 1 °F)
Reset time at emergency start	20 to 150000 s (steps 1 s)
Drop-off ratio	
Θ/Θ_{Trip}	Drop-off with Θ_{Alarm}
Θ/Θ_{Alarm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.95
Tolerances	
Regarding k x I_P	2 % or 10/50 mA; class 2 % according to IEC 60255-8
Regarding trip time	3 % or 1 s: class 3 % according to IEC 60255-8 for $I/(k\ I_N)>1.25$

Technical data

Negative-sequence protection *(ANSI 46)*

Setting ranges	
Permissible negative sequence I_2 perm. $/I_N$	3 to 30 % (steps 1 %)
Definite time trip stage $I_2>>/I_N$	10 to 100 % (steps 1 %)
Time delays T_{Alarm}; $T_{I2>>}$	0 to 60 s (steps 0.01 s) or indefinite
Negative-sequence factor k	2 to 40 s (steps 0.1 s)
Cooling down time $T_{Cooling}$	0 to 50000 s (steps 1 s)
Times	
Pickup time (definite stage)	Approx. 50 ms
Drop-off time (definite stage)	Approx. 50 ms
Drop-off ratios I_2 perm.; $I_2>>$	Approx. 0.95
Drop-off ratio thermal stage	Drop-off at fall below of I_2 perm.
Tolerances	
Pickup values I_2 perm.; $I_2>>$	3 % of set value or 0.3 % negative sequence
Time delays	1 % or 10 ms
Thermal characteristic Time for $2 \leq I_2/I_2$ perm. ≤ 20	5 % of nominal value +1 % current tolerance or 600 ms

Underexcitation protection *(ANSI 40)*

Setting ranges	
Conductance thresholds 1/xd characteristic (3 characteristics)	0.25 to 3.0 (steps 0.01)
Inclination angle $\alpha_1, \alpha_2, \alpha_3$	50 to 120 ° (steps 1 °)
Time delay T	0 to 50 s (steps 0.01 s) or indefinite
Times	
Stator criterion 1/xd characteristic; α	Approx. 60 ms
Undervoltage blocking	Approx. 50 ms
Drop-off ratio	
Stator criterion 1/xd characteristic; α	Approx. 0.95
Undervoltage blocking	Approx. 1.1
Tolerances	
Stator criterion 1/xd characteristic	3 % of set value
Stator criterion α	1 ° electrical
Undervoltage blocking	1 % or 0.5 V
Time delays T	1 % or 10 ms

Reverse-power protection *(ANSI 32R)*

Setting ranges	
Reverse power $P_{Rev.>}/S_N$	–0.5 to –30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.>}$	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.>}$	0.25 % S_N ± 3 % set value
Time delays T	1 % or 10 ms

Forward-power protection *(ANSI 32F)*

Setting ranges	
Forward power $P_{Forw.<}/S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{Forw.>}/S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{Forw.<}$	1.1 or 0.5 % of S_N
Drop-off ratio $P_{Forw.>}$	Approx. 0.9 or –0.5 % of S_N
Tolerances	
Active power $P_{Forw.<}$, $P_{Forw.>}$	0.25 % S_N ± 3 % of set value at $Q < 0.5\ S_N$ at accurate measuring 0.5 % S_N ± 3 % of set value at $Q < 0.5\ S_N$ at fast measuring
Time delays T	1 % or 10 ms

Impedance protection *(ANSI 21)*

Setting ranges	
Overcurrent pickup $I>$	0.1 to 4 A (steps 0.01 A); 5 times at I_N = 5A
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1V)
Impedance Z1 (related to I_N =1 A)	0.05 to 130 Ω (steps 0.01 Ω)
Impedance Z1B (related to I_N =1 A)	0.05 to 65 Ω (steps 0.01 Ω)
Impedance Z2 (related to I_N =1 A)	0.05 to 65 Ω (steps 0.01 Ω)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Shortest tripping time	Approx. 40 ms
Drop-off time	Approx. 50 ms
Drop-off ratio	
Overcurrent pickup $I>$	Approx. 0.95
Undervoltage seal-in $V<$	Approx. 1.05
Tolerances	
Overcurrent pickup $I>$	1 % of set value. 10/50 mA
Undervoltage seal-in $V<$	1 % of set value. or 0.5 V
Impedance measuring Z1, Z2	$\|\Delta Z/Z\| \leq 5$ % for 30 ° $\leq \varphi_K \leq$ 90 °
Time delays T	1 % or 10 ms

Undervoltage protection *(ANSI 27)*

Setting range	
Undervoltage pickup $V<$, $V<<$ (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time $V<$, $V<<$	Approx. 50 ms
Drop-off time $V<$, $V<<$	Approx. 50 ms
Drop-off ratio $V<$, $V<<$	1.01 to 1.1 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Technical data

Overvoltage protection (ANSI 59)	
Setting ranges	
Overvoltage pickup V>, V>> (maximum phase-to-phase voltage or phase-to-earth-voltage)	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time	
Pickup times V>, V>>	Approx. 50 ms
Drop-off times V>, V>>	Approx. 50 ms
Drop-off ratio V>, V>>	0.9 to 0.99 (steps 0.01)
Tolerances	
Voltage limit value	1 % of set value 0.5 V
Time delays T	1 % or 10 ms
Frequency protection (ANSI 81)	
Setting ranges	
Steps; selectable f>, f<	4
Pickup values f>, f<	40 to 65 Hz (steps 0.01 Hz)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Times	
Pickup times f>, f<	Approx. 100 ms
Drop-off times f>, f<	Approx. 100 ms
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio V_1<	Approx. 1.05
Tolerances	
Frequency	10 mHz (at V> 0.5 V_N)
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms
Overexcitation protection (Volt/Hertz) (ANSI 24)	
Setting ranges	
Pickup threshold alarm stage	1 to 1.2 (steps 0.01)
Pickup threshold V/f>>-stage	1 to 1.4 (steps 0.01)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Characteristic values of V/f	1.1/1.15/1.2/1.25/1.3/1.35/1.4
and assigned times t(V/f)	0 to 20000 s (steps 1 s)
Cooling down time $T_{Cooling}$	0 to 20000 s (steps 1 s)
Times (Alarm and V/f>>-stage)	
Pickup times at 1.1 of set value	Approx. 60 ms
Drop-off times	Approx. 60 ms
Drop-off ratio (alarm, trip)	0.95
Tolerances	
V/f-pickup	3 % of set value
Time delays T	1 % or 10 ms
Thermal characteristic (time)	5 % rated to V/f or 600 ms

90 % stator earth-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)	
Setting ranges	
Displacement voltage V_0 >	5 to 125 V (steps 0.1 V)
Earth current $3I_0$ >	2 to 1000 mA (steps 1 mA)
Angle of direction element	0 to 360 ° (steps 1 °)
Time delays T	0 to 60 s (steps 0,01 s) or indefinite
Times	
Pickup times V_0>, $3I_0$>	Approx. 50 ms
Drop-off times V_0>/ $3I_0$>	Approx. 50 ms
Drop-off ratio V_0>, $3I_0$>	0.7
Drop-off difference angle	10 ° directed to power system
Tolerances	
Displacement voltage	1 % of set value or 0.5 V
Earth current	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms
Sensitive earth-fault protection (ANSI 50/51GN, 64R)	
Setting ranges	
Earth current pickup I_{EE}>, I_{EE}>>	2 to 1000 mA (steps 1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Measuring circuit supervision I_{EE}<	1.5 to 50 mA (steps 0.1 mA)
Times	
Pickup times	Approx. 50 ms
Drop-off times	Approx. 50 ms
Measuring circuit supervision	Approx. 50 ms
Drop-off ratio I_{EE}>, I_{EE}>>	0.95 or 1 mA
Drop-off ratio measuring circuit supervision I_{EE}<	Approx. 1.1 or 1 mA
Tolerances	
Earth current pickup	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms
100 % stator earth-fault protection with 3rd harmonics (ANSI 59TN, 27TN (3rd H.))	
Setting ranges	
Displacement voltage $V_{0\,(3^{rd}\,harm.)}$>, $V_{0\,(3^{rd}\,harm.)}$<	0.2 to 40 V (steps 0.1 V)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Active-power release	10 to 100 % (steps 1 %) or indefinite
Positive-sequence voltage release	50 to 125 V (steps 0.1 V) or indefinite
Times	
Pickup time	Approx. 80 ms
Drop-off time	Approx. 80 ms
Drop-off ratio	
Undervoltage stage $V_{0\,(3^{rd}\,harm.)}$<	Approx. 1.4
Overvoltage stage $V_{0\,(3^{rd}\,harm.)}$>	Approx. 0.6
Active-power release	Approx. 0.9
Positive-sequence voltage release	Approx. 0.95
Tolerances	
Displacement voltage	3 % of set value or 0.1 V
Time delay T	1 % or 10 ms

11

Technical data

Breaker failure protection (ANSI 50BF)	
Setting ranges	
Current thresholds I>BF	0.04 to 1 A (steps 0.01 A)
Time delay BF-T	0.06 to 60 s (steps 0.01 s) or indefinite
Time	
Pickup time	Approx. 50 ms
Drop-off time	Approx. 50 ms
Tolerances	
Current threshold I>BF/I_N	1 % of set value or 10/50 mA
Time delay T	1 % or 10 ms

Inadvertent energizing protection (ANSI 50, 27)	
Setting ranges	
Current pickup I>>>	0.1 to 20 A (steps 0.1 A); 5 times at I_N= 5 A
Voltage release V_1<	10 to 125 V (steps 1 V)
Time delay	0 to 60 s (steps 0.01 s) or indefinite
Drop-off time	0 to 60 s (steps 0.01 s) or indefinite
Times	
Reaction time	Approx. 25 ms
Drop-off time	Approx. 35 ms
Drop-off ratio I>>>	Approx. 0.8
Drop-off ratio V_1<	Approx. 1.05
Tolerances	
Current pickup	5 % of set value or 20/100 mA
Undervoltage seal-in V_1<	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

External trip coupling	
Number of external trip couplings	2 for 7UM611 4 for 7UM612

Trip circuit supervision (ANSI 74TC)	
Number of supervised trip circuits (only 7UM612)	1

Starting time supervision for motors (ANSI 48)	
Setting ranges	
Motor starting current $I_{Start\ max}$ /I_N	1.0 to 16 (steps 0.01)
Starting current pickup $I_{Start,\ pickup.}$ /I_N	0.6 to 10 (steps 0.01)
Permissible starting time $T_{Start\ max}$	1.0 to 180 s (steps 0.1 s)
Permissible locked rotor time $T_{Blocking}$	0.5 to 120 s (steps 0.1 s) or indefinite
Times	Depending on the settings
Drop-off ratio	Approx. 0.95
Tolerances	
Current threshold	1 % of set value, or 1 % of I_N
Time delays T	5 % or 30 ms

Restart inhibit for motors (ANSI 66, 49 Rotor)	
Setting ranges	
Motor starting current $I_{Start\ max}$ /I_N	3.0 to 10.0 (steps 0.01)
Permissible starting time $T_{Start\ max}$	3.0 to 120.0 s (steps 0.1 s)
Rotor temperature equalization time $T_{Equali.}$	0 to 60.0 min (steps 0,1 min)
Minimum restart inhibit time $T_{Restart,\ min}$	0.2 to 120.0 min (steps 0.1 min)
Permissible number of warm starts n_W	1 to 4
Difference between warm and cold starts n_K-n_W	1 to 2
Extensions of time constants (running and stop)	1.0 to 100.0
Tolerances	
Time delays T	1 % or 0.1 ms

Rate-of-frequency-change protection (ANSI 81R)	
Setting ranges	
Steps, selectable +df/dt >; - df/dt	4
Pickup value df/dt	0.2 to 10 Hz/s (steps 0.1 Hz/s);
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Times	
Pickup times df/dt	Approx. 200 ms
Drop-off times df/dt	Approx. 200 ms
Drop-off ratio df/dt	Approx. 0.95 or 0.1 Hz/s
Drop-off ratio V<	Approx. 1.05
Tolerances	
Rate-of-frequency change	Approx. 0.1 Hz/s at V> 0.5 V_N
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Vector jump supervision (voltage)	
Setting ranges	
Stage $\Delta\varphi$	0.5 ° to 15 ° (steps 0.1 °)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Tolerances	
Vector jump	0.3 ° at V> 0.5 V_N
Undervoltage blocking	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

Incoupling of temperature via serial interface (thermo-box) (ANSI 38)	
Number of measuring sensors	6 or 12
Temperature thresholds	40 to 250 °C or 100 to 480 °F (steps 1 °C or 1 °F)
Sensor types	Pt100; Ni 100, Ni 120

11

Technical data

Operational measured values	
Description	Primary; secondary or per unit (%)
Currents Tolerance	I_{L1}; I_{L2}; I_{L3}; I_{EE}; I_1; I_2 0.2 % of measured values or ± 10 mA ± 1 digit
Voltages Tolerance	V_{L1}; V_{L2}; V_{L3}; V_E; V_{L12}; V_{L23}; V_{L31}; V_1; V_2 0.2 % of measured values or ± 0.2 V ± 1 digit
Impedance Tolerance	R, X 1 %
Power Tolerance	S; P; Q 1 % of measured values or ± 0.25 % S_N
Phase angle Tolerance	φ <0.1 °
Power factor Tolerance	cos φ (p.f.) 1 % ± 1 digit
Frequency Tolerance	f 10 mHz at (V> 0.5 V_N; 40 Hz < f < 65 Hz)
Overexcitation Tolerance	V/f; 1 %
Thermal measurement Tolerance	Θ_{L1}; Θ_{L2}, Θ_{L3}, Θ_{I2}, $\Theta_{V/f}$, 5 %
Min./max. memory	
Memory	Measured values with date and time
Reset manual	Via binary input Via key pad Via communication
Values Positive sequence voltage Positive sequence current Active power Reactive power Frequency Displacement voltage (3rd harmonics)	 V_1 I_1 P Q f $V_{E(3^{rd}\ harm.)}$
Energy metering	
Meter of 4 quadrants Tolerance	W_{P+}; W_{P-}; W_{Q+}; W_{Q-} 1 %
Fault records	
Number of fault records	Max. 8 fault records
Instantaneous values Storage time Sampling interval Channels	Max. 5 s Depending on the actual frequency (e. g. 1.25 ms at 50 Hz; 1.04 ms at 60 Hz)) v_{L1}, v_{L2}, v_{L3}, v_E; i_{L1}, i_{L2}, i_{L3}, i_{EE}
R.m.s. values Storage period Sampling interval Channels	 Max. 80 s Fixed (20 ms at 50 Hz; 16.67 ms at 60 Hz) V_1, V_E, I_1, I_2, I_{EE}, P, Q, φ, f-f_n

Additional functions	
Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits (criterion: current threshold)
Switching statistics	Number of breaker operation Phase-summated tripping current

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

11

Selection and ordering data

Description	Order No.	Order Code
7UM61 multifunction generator and motor protection relay	7UM61□□-□□□□□-□□□0	□□□

Housing, binary inputs and outputs	
Housing 1/3 19", 7 BI, 11 BO, 1 live status contact	1
Housing 1/2 19", 15 BI, 19 BO, 1 live status contact	2

Current transformer I_N	
1 A 1)	1
5 A 1)	5

Rated auxiliary voltage (power supply, indication voltage)	
24 to 48 V DC, threshold binary input 19 V 3)	2
60 to 125 V DC 2), threshold binary input 19 V 3)	4
110 to 250 V DC 2), 115/230 V AC, threshold binary input 88 V 3)	5

Unit version	
For panel surface mounting, 2 tier screw-type terminals top/bottom	B
For panel flush mounting, plug-in terminals (2-/3- pin connector)	D
Flush-mounting housing, screw-type terminal (direct connection, ring-type cable lugs)	E

Region-specific default setting/function and language settings	
Region DE, 50 Hz, IEC characteristics, language: German, (language can be selected)	A
Region World, 50/60 Hz, IEC/ANSI characteristics, language: English (UK), (language can be selected)	B
Region US, 60 Hz, ANSI characteristics, language: English (US), (language can be selected)	C

System interface (rear of units)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-DP slave, electrical RS485	9	L 0 A
PROFIBUS-DP slave, optical 820 nm, double ring, ST connector*	9	L 0 B
MODBUS, electrical RS485	9	L 0 D
MODBUS, optical 820 nm, ST connector*	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector*	9	L 0 H

DIGSI 4/modem interface (rear of unit)	
No interface	0
DIGSI 4, electrical RS232	1
DIGSI 4, temperature monitoring box, electrical RS485	2
DIGSI 4, temperature monitoring box, optical 820 nm, ST connector	3

Measuring functions	
Without	0
Min./max. values, energy metering	3

Functions 4)	
Generator Basic	A
Generator Standard	B
Generator Full	C
Motor, asynchronous	F

Additional functions 4)	
Without	A
Network decoupling (df/dt and vector jump)	E

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected in stages by means of jumpers.

4) For more detailed information on the functions see Table 11/1 on page 11/4.

* Not with position 9 = B; if 9 = “B”, please order 7UM61 unit with RS485 port and separate fiber-optic converters.

11

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Profesional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional Edition. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
Connecting cable Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
Coupling device for rotor earth-fault protection	7XR6100-0CA00
	Short code
Series resistor for rotor earth-fault protection (group: 013002)	3PP1336-0DZ K2Y
Resistor for stator earth-fault protection (voltage divider, 5 : 1) (group 013001)	3PP1336-1CZ K2Y
Temperature monitoring box (thermo-box) 24 to 60 V AC/DC	7XV5662-2AD10
90 to 240 V AC/DC	7XV5662-5AD10
Manual for 7UM61 English	C53000-G1176-C127-2

11

Accessories

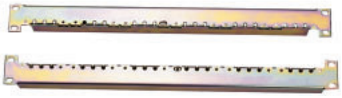


Fig. 11/26 Mounting rail for 19" rack

Fig. 11/27
2-pin connector

Fig. 11/28
3-pin connector

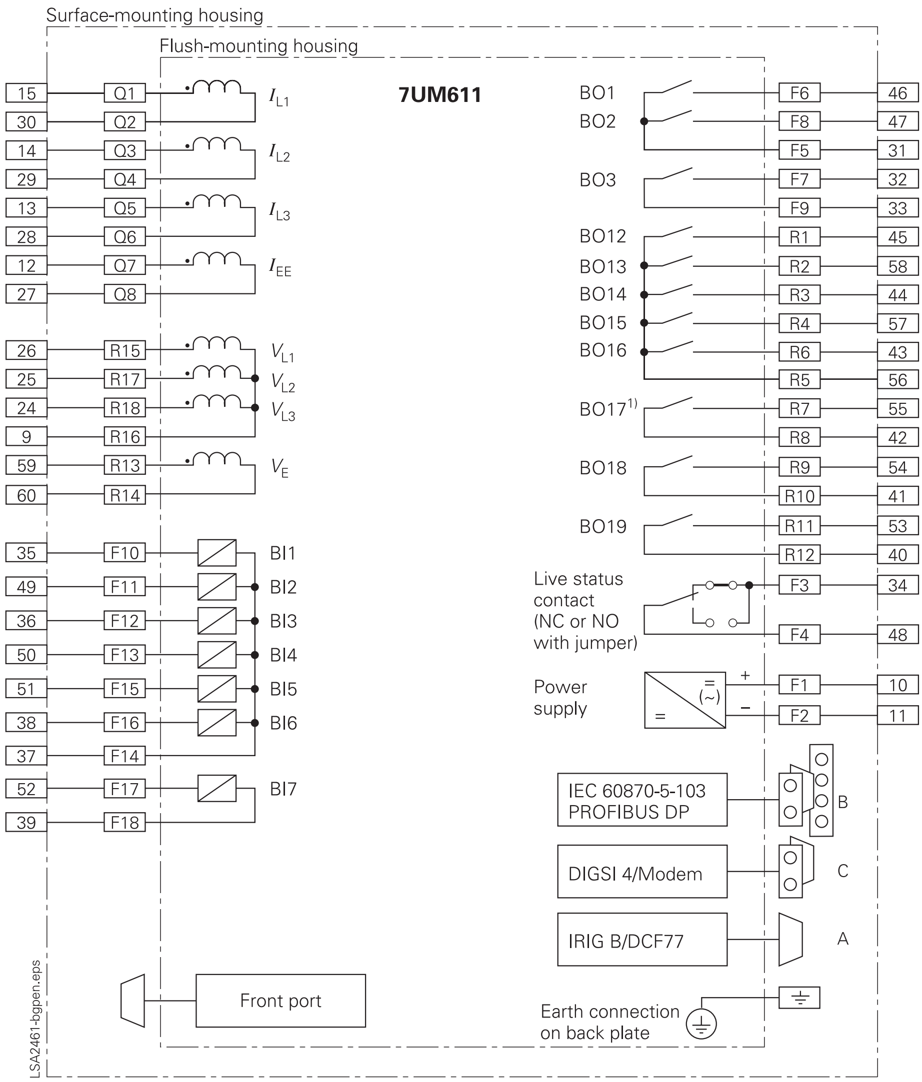
Fig. 11/29
Short-circuit link for current terminals

Fig. 11/30
Short-circuit link for voltage terminals/indications terminals

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	11/27
	3-pin	*C73334-A1-C36-1*	1	Siemens	11/28
Crimp connector	CI2 0.5 to 1 mm^2	*0-827039-1*	4000	AMP [1)]	
		0-827396-1	1	AMP [1)]	
	CI2 1 to 2.5 mm^2	*0-827040-1*	4000	AMP [1)]	
		0-827397-1	1	AMP [1)]	
	Type III+ 0.75 to 1.5 mm^2	*0-163083-7*	4000	AMP [1)]	
		0-163084-2	1	AMP [1)]	
Crimping tool	For Type III+	*0-539635-1*	1	AMP [1)]	
	and matching female	*0-539668-2*		AMP [1)]	
	For CI2	*0-734372-1*	1	AMP [1)]	
	and matching female	*1-734387-1*		AMP [1)]	
Mounting rail		*C73165-A63-D200-1*	1	Siemens	11/26
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	11/29
	For other terminals	*C73334-A1-C34-1*	1	Siemens	11/30
Safety cover for terminals	Large	*C73334-A1-C31-1*	1	Siemens	11/3
	Small	*C73334-A1-C32-1*	1	Siemens	11/3

1) Your local Siemens representative can inform you on local suppliers.

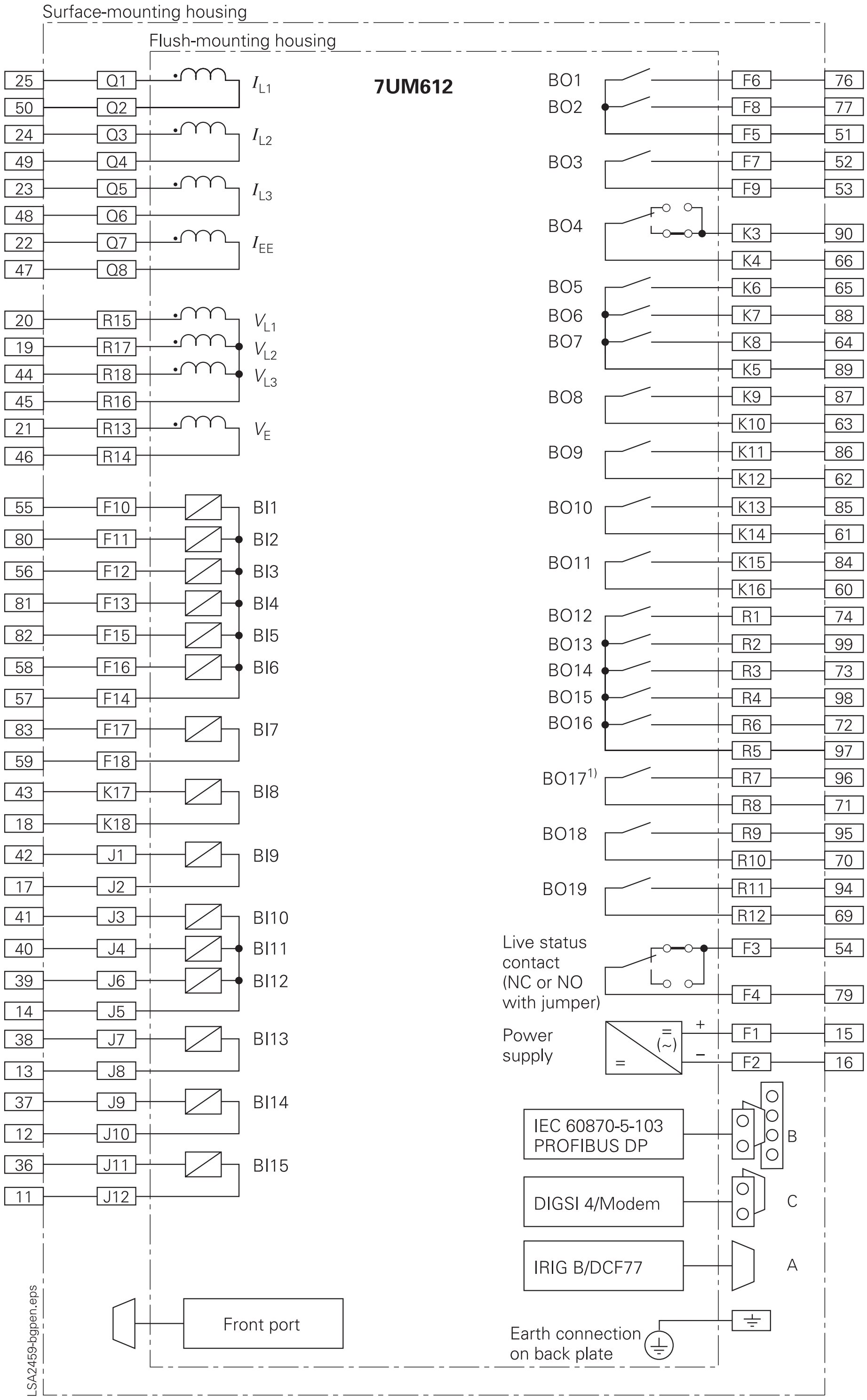
Connection diagram, IEC



1) NO or NC with jumper possible.

Fig. 11/31
7UM611 connection diagram (IEC standard)

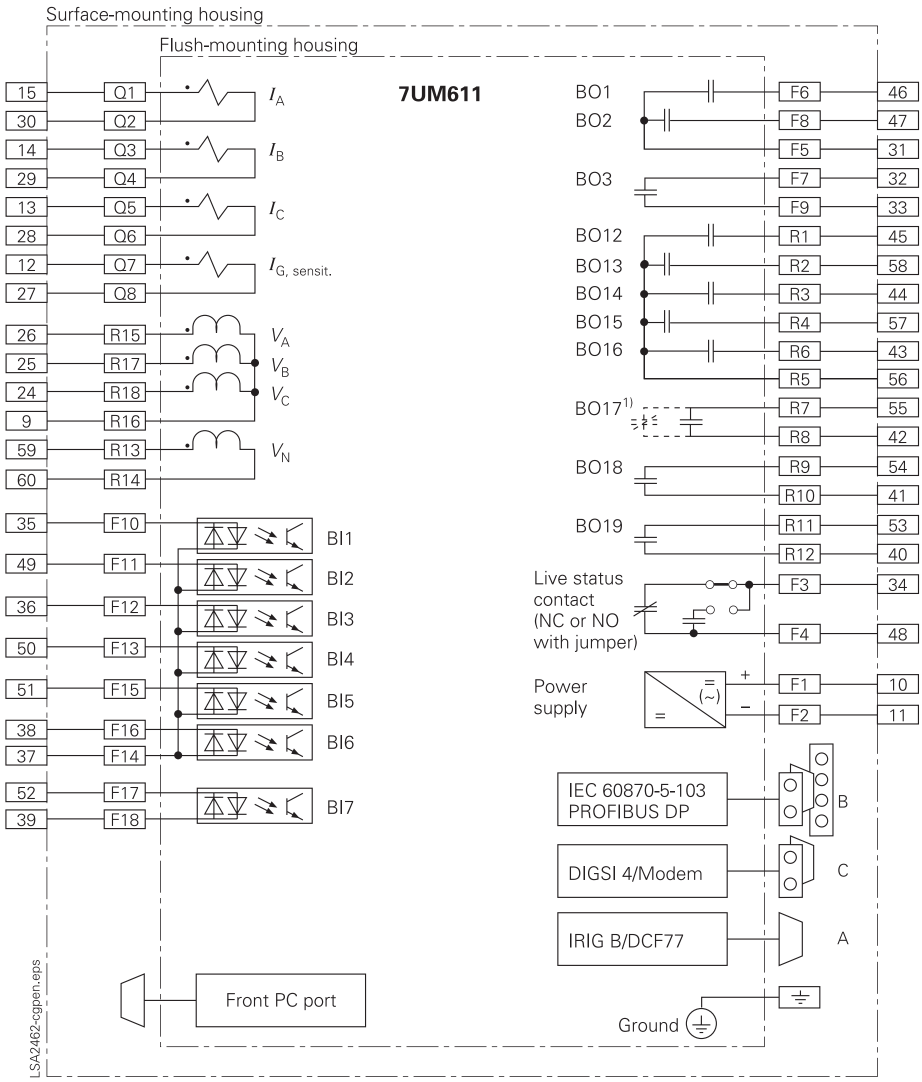
Connection diagram, IEC



1) NO or NC with jumper possible.

Fig. 11/32
7UM612 connection diagram (IEC standard)

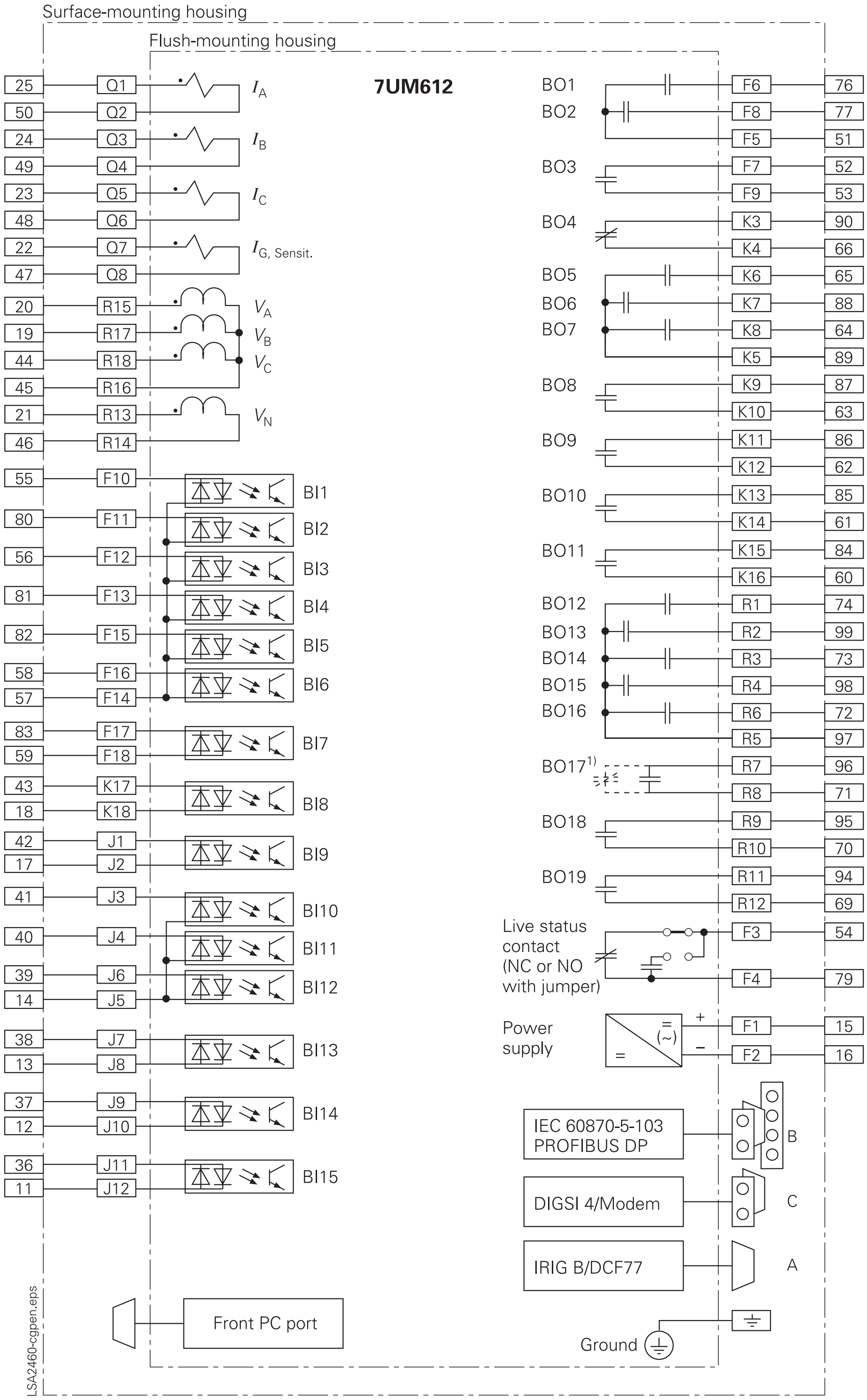
Connection diagram, ANSI



1) NO or NC with jumper possible.

Fig. 11/33
7UM611 connection diagram (ANSI standard)

Connection diagram, ANSI



1) NO or NC with jumper possible.

Fig. 11/34
7UM612 connection diagram (ANSI standard)

SIPROTEC 4 7UM62
Multifunction Generator, Motor and Transformer Protection Relay

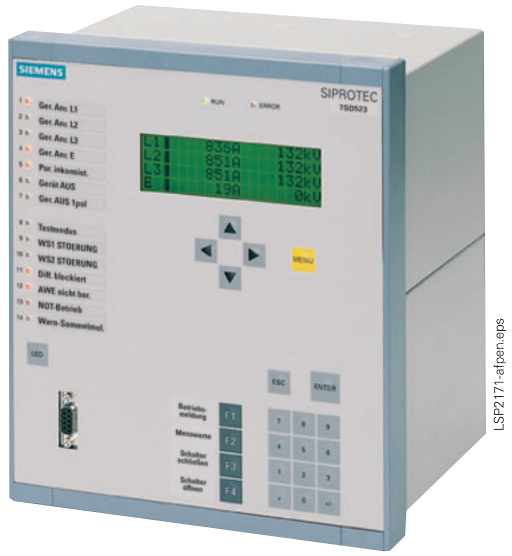


Fig. 11/35 SIPROTEC 4 7UM62 multifunction protection relay for generators, motors and transformers

Description

The SIPROTEC 4 7UM62 protection relays can do more than just protect. They also offer numerous additional functions. Be it earth faults, short-circuits, overloads, overvoltage, overfrequency or underfrequency asynchronous conditions, protection relays assure continued operation of power stations. The SIPROTEC 4 7UM62 protection relay is a compact unit which has been specially developed and designed for the protection of small, medium-sized and large generators. They integrate all the necessary protection functions and are particularly suited for the protection of:

– Hydro and pumped-storage generators
– Co-generation stations
– Private power stations using regenerative energy sources such as wind or biogases
– Diesel generator stations
– Gas-turbine power stations
– Industrial power stations
– Conventional steam power stations.

The SIPROTEC 4 7UM62 includes all necessary protection functions for large synchronous and asynchronous motors and for transformers.

The integrated programmable logic functions (continuous function chart CFC) offer the user high flexibility so that adjustments can easily be made to the varying power station requirements on the basis of special system conditions.
The flexible communication interfaces are open for modern communication architectures with the control system.

The following basic functions are available for all versions:

Current differential protection for generators, motors and transformers, stator earth-fault protection, sensitive earth-fault protection, stator overload protection, overcurrent- time protection (either definite time or inverse time), definite-time overcurrent protection with directionality, undervoltage and overvoltage protection, underfrequency and overfrequency protection, overexcitation and underexcitation protection, external trip coupling, forward-power and reverse-power protection, negative-sequence protection, breaker failure protection, rotor earth-faults protection (f_n, R-measuring), motor starting time supervision and restart inhibit for motors.

Function overview

Standard version

Scope of basic version plus:

- Inadvertent energization protection
- 100 %-stator earth-fault protection with 3rd harmonic
- Impedance protection

Full version

Scope of standard version plus:

- DC voltage protection
- Overcurrent protection during start-ups
- Earth-current differential protection
- Out-of-step protection

Additional version

Available for each version:

- Sensitive rotor earth-fault protection (1-3 Hz method)
- Stator earth-fault protection with 20 Hz voltage
- Rate-of-frequency-change protection
- Vector jump supervision

Monitoring function

- Trip circuit supervision
- Fuse failure monitor
- Operational measured values $V, I, f, \ldots$
- Energy metering values W_p, W_q
- Time metering of operating hours
- Self-supervision of relay
- 8 oscillographic fault records

Communication interfaces

- System interface
  – IEC 61850 protocol
  – IEC 60870-5-103 protocol
  – PROFIBUS-DP
  – MODBUS RTU
  – DNP 3.0

Hardware

- Analog inputs
- 8 current transformers
- 4 voltage transformers
- 7/15 binary inputs
- 12/20 output relays

Front design

- User-friendly local operation
- 7/14 LEDs for local alarm
- Function keys
- Graphic display with 7UM623

11

Application

The 7UM6 protection relays of the SIPROTEC 4 family are compact multi-function units which have been developed for small to medium-sized power generation plants. They incorporate all the necessary protective functions and are especially suitable for the protection of:

– Hydro and pumped-storage generators
– Co-generation stations
– Private power stations using regenerative energy sources such as wind or biogases
– Power generation with diesel generators
– Gas turbine power stations
– Industrial power stations
– Conventional steam power stations.

They can also be employed for protection of motors and transformers.

The numerous other additional functions assist the user in ensuring cost-effective system management and reliable power supply. Measured values display current operating conditions. Stored status indications and fault recording provide assistance in fault diagnosis not only in the event of a disturbance in generator operation.

Combination of the units makes it possible to implement effective redundancy concepts.

Protection functions

Numerous protection functions are necessary for reliable protection of electrical machines. Their extent and combination are determined by a variety of factors, such as machine size, mode of operation, plant configuration, availability requirements, experience and design philosophy.

This results in multifunctionality, which is implemented in outstanding fashion by numerical technology.

In order to satisfy differing requirements, the combination of functions is scalable (see Table 11/3). Selection is facilitated by division into five groups.

Generator Basic

One application concentrates on small and medium generators for which differential protection is required. The function mix is also suitable as backup protection. Protection of synchronous motors is a further application.

Generator Standard

In the case of medium-size generators (10 to 100 MVA) in a unit connection, this scope of functions offers all necessary protection functions. Besides inadvertent energization protection, it also includes powerful backup protection for the transformer or the power system. The scope of protection is also suitable for units in the second protection group.

Generator Full

Here, all protection functions are available and the main application focuses on large block units (more than 100 MVA). The function mix includes all necessary protection functions for the generator as well as backup protection for the block transformer including the power system. Additional functions such as protection during start-up for generators with starting converters are also included.

The scope of functions can be used for the second protection group, and functions that are not used, can be masked out.

Asynchronous motor

Besides differential protection, this function package includes all protection functions needed to protect large asynchronous motors (more than 1 MVA). Stator and bearing temperatures are measured by a separate thermo-box and are transmitted serially to the protection unit for evaluation.

Transformer

This scope of functions not only includes differential and overcurrent protection, but also a number of protection functions that permit monitoring of voltage and frequency stress, for instance. The reverse-power protection can be used for energy recovery monitoring of parallel-connected transformers.

Construction

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control.

Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays were a major design aim. The 7UM623 is equipped with a graphic display thus providing and depicting more information especially in industrial applications. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

The 7UM621 and 7UM623 are configured in 1/2 19 inches width. This means that the units of previous models can be replaced. The height throughout all housing width increments is 243 mm.

All wires are connected directly or by means of ring-type cable lugs. Alternatively, versions with plug-in terminals are also available. These permit the use of prefabricated cable harnesses.

In the case of panel surface mounting, the connecting terminals are in the form of screw-type terminals at top and bottom. The communication interfaces are also arranged on the same sides.

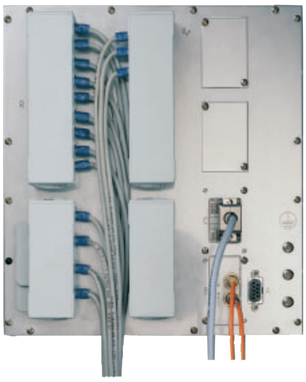

LSP2166-afpen.eps

Fig. 11/36
Rear view with wiring terminal safety cover and serial interface

11

Protection functions

Protection functions	Abbre-viation	ANSI No.	Gene-rator Basic	Gene-rator Standard	Gene-rator Full	Motor Asyn-chronous	Trans-former
Current differential protection	ΔI	87G/87T/87M	X	X	X	X	X
Stator earth-fault protection non-directional, directional	$V_0>$, $3I_0>$ \(V_0, $3I_0$)	59N, 64G 67G	X	X	X	X	X
Sensitive earth-fault protection (also rotor earth-fault protection)	$I_{EE}>$	50/51GN (64R)	X	X	X	X	X
Sensitive earth-fault prot. B (e.g. shaft current prot.)	$I_{EE\text{-}B}>$ $I_{EE\text{-}B}<$	51GN	X	X	X	X	X
Stator overload protection	I^2t	49	X	X	X	X	X
Definite-time overcurrent prot. with undervolt. seal-in	$I> +V<$	51	X	X	X	X	X
Definite-time overcurrent protection, directional	$I>>$, Direc.	50/51/67	X	X	X	X	X
Inverse-time overcurrent protection	$t = f(I)+V<$	51V	X	X	X	X	X
Overvoltage protection	$V>$	59	X	X	X	X	X
Undervoltage protection	$V<$, $t = f$ (V)	27	X	X	X	X	X
Frequency protection	$f<$, $f>$	81	X	X	X	X	X
Reverse-power protection	$-P$	32R	X	X	X	X	X
Overexcitation protection (Volt/Hertz)	V/f	24	X	X	X	X	X
Fuse failure monitor	V_2/V_1, I_2/I_1	60FL	X	X	X	X	X
External trip coupling	Incoup.		4	4	4	4	4
Trip circuit supervision	T.C.S.	74TC	X	X	X	X	X
Forward-power protection	$P>$, $P<$	32F	X	X	X	X	X
Underexcitation protection (loss-of-field protection)	1/xd	40	X	X	X		
Negative-sequence protection	$I_2>$, $t = f(I_2)$	46	X	X	X	X	
Breaker failure protection	$I_{min}>$	50BF	X	X	X	X	X
Motor starting time supervision	$I_{start}{}^2t$	48	X	X	X	X	
Restart inhibit for motors	I^2t	66, 49 Rotor	X	X	X	X	
Rotor earth-fault protection (f_n, R-measuring)	$R<$	64R (f_n)	X	X	X		
Inadvertent energization protection	$I>$, $V<$	50/27		X	X		
100 % stator earth-fault protection with 3rd harmonics	$V_{0(3rd\ harm.)}$	59TN, 27TN 3rd h		X	X		
Impedance protection with ($I>+V<$) pickup	$Z<$	21		X	X		
Interturn protection	$U_{Interturn}>$	59N(IT)		X	X		
DC voltage / DC current time protection	$V_{dc}>$ $I_{dc}>$	59N (DC) 51N (DC)			X		
Overcurrent protection during startup (for gas turbines)	$I>$	51			X		
Earth-current differential protection	ΔI_e	87GN/TN	X 1)	X 1)	X	X 1)	X 1)
Out-of-step protection	$\Delta Z/\Delta t$	78			X		
Rotor earth-fault protection (1-3 Hz square wave voltage)	$R_{REF}<$	64R (1–3 Hz)	X 1)	X 1)	X 1)		
100 % stator earth-fault protection with 20 Hz voltage	$R_{SEF}<$	64G (100 %)	X 1)	X 1)	X 1)		
Rate-of-frequency-change protection	$df/dt>$	81R	X 1)	X 1)	X 1)	X 1)	X 1)
Vector jump supervision (voltage)	$\Delta\varphi>$		X 1)	X 1)	X 1)	X 1)	X 1)
Threshold supervision			X	X	X	X	X
Supervision of phase rotation	A, B, C	47	X	X	X	X	X
Undercurrent via CFC	$I<$	37	X	X	X	X	X
External temperature monitoring via serial interface	ϑ (Thermo-box)	38	X	X	X	X	X

Table 11/3 Scope of functions of the 7UM62

1) Optional for all function groups.

Protection functions

Current differential protection (ANSI 87G, 87M, 87T)

This function provides undelayed short-circuit protection for generators, motors and transformers, and is based on the current differential protection principle (Kirchhoff's current law).

The differential and restraint (stabilization) current are calculated on the basis of the phase currents. Optimized digital filters reliably attenuate disturbances such as aperiodic component and harmonics. The high resolution of measured quantities permits recording of low differential currents (10 % of I_N) and thus a very high sensitivity.

An adjustable restraint characteristic permits optimum adaptation to the conditions of the protected object. Software is used to correct the possible mismatch of the current transformers and the phase angle rotation through the transformer (vector group). Thanks to harmonic analysis of the differential current, inrush (second harmonic) and overexcitation (fifth harmonic) are reliably detected, and unwanted operation of the differential protection is prevented. The current of internal short-circuits is reliably measured by a fast measuring stage (I_{Diff}>>), which operates with two mutually complementary measuring processes. An external short-circuit with transformer saturation is picked up by a saturation detector with time and status monitoring. It becomes active when the differential current (I_{Diff}) moves out of the add-on restraint area.

If a motor is connected, this is detected by monitoring the restraint current and the restraint characteristic is briefly raised. This prevents false tripping in the event of unequal current transmission by the current transformers.

Figure 11/37 shows the restraint characteristic and various areas.

Earth-current differential protection (ANSI 87GN, 87TN)

The earth-current differential protection permits high sensitivity to single-pole faults. The zero currents are compared. On the one hand, the zero-sequence current is calculated on the basis of the phase currents and on the other hand, the earth current is measured directly at the star-point current transformer.

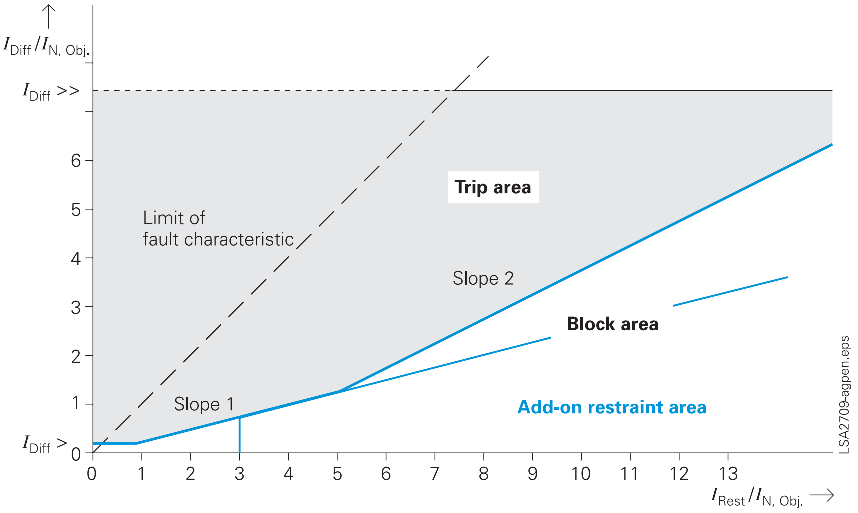


Fig. 11/37 Restraint characteristic of current differential protection

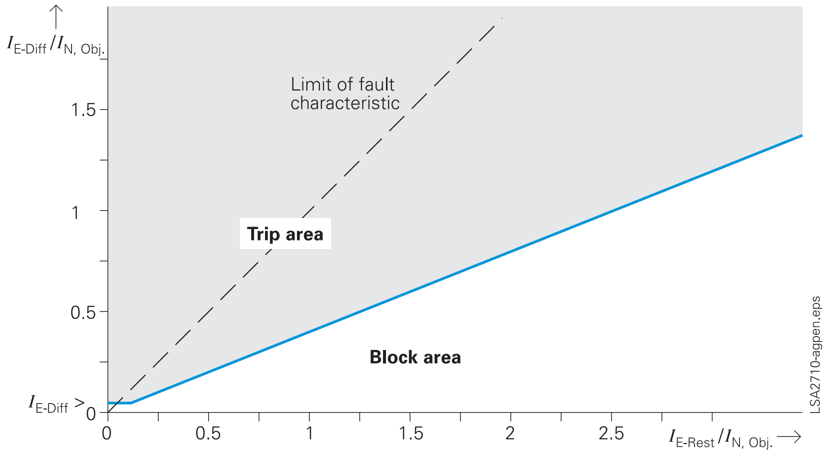


Fig. 11/38 Restraint characteristic of earth-current differential protection

The differential and restraint quantity is generated and fitted into the restraint characteristic (see Fig. 11/38).

DC components in particular are suppressed by means of specially dimensioned filters. A number of monitoring processes avoid unwanted operation in the event of external short-circuits. In the case of a sensitive setting, multiple measurement ensures the necessary reliability.

However, attention must be drawn to the fact that the sensitivity limits are determined by the current transformers.

The protection function is only used on generators when the neutral point is earthed with a low impedance. In the case of transformers, it is connected on the neutral side. Low impedance or solid earthing is also required.

Protection functions

Definite-time overcurrent protection $I>$, $I>>$ (ANSI 50, 51, 67)

This protection function comprises the short-circuit protection for the generator and also the backup protection for upstream devices such as transformers or power system protection.

An undervoltage stage at $I>$ maintains the pickup when, during the fault, the current drops below the threshold. In the event of a voltage drop on the generator terminals, the static excitation system can no longer be sufficiently supplied. This is one reason for the decrease of the short-circuit current.

The $I>>$ stage can be implemented as high-set instantaneous trip stage. With the integrated directional function it can be used as backup protection on the transformer high-voltage side. With the information of the directional element, impedance protection can be controlled via the CFC.

Inverse-time overcurrent protection (ANSI 51V)

This function also comprises short-circuit and backup protection and is used for power system protection with current-dependent protection devices.

IEC and ANSI characteristics can be selected (Table 11/4).

The current function can be controlled by evaluating the generator terminal voltage.

The "controlled" version releases the sensitive set current stage.

With the "restraint" version, the pickup value of the current is lowered linearly with decreasing voltage.

The fuse failure monitor prevents unwanted operation.

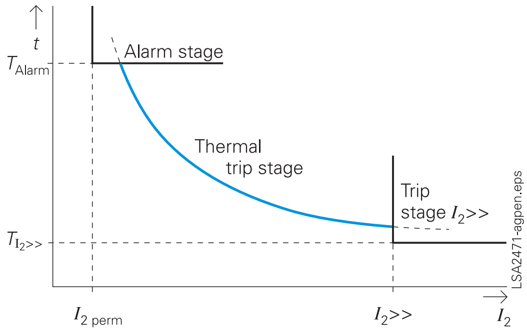


Fig. 11/39 Characteristic of negative-sequence protection

Stator overload protection (ANSI 49)

The task of the overload protection is to protect the stator windings of generators and motors from high, continuous overload currents. All load variations are evaluated by a mathematical model. The thermal effect of the r.m.s. current value forms the basis of the calculation.
This conforms to IEC 60255-8.
In dependency of the current, the cooling time constant is automatically extended. If the ambient temperature or the temperature of the coolant are injected via a transducer (TD2) or PROFIBUS-DP, the model automatically adapts to the ambient conditions; otherwise a constant ambient temperature is assumed.

Negative-sequence protection (ANSI 46)

Asymmetrical current loads in the three phases of a generator cause a temperature rise in the rotor because of the negative-sequence field produced.

This protection detects an asymmetrical load in three-phase generators. It functions on the basis of symmetrical components and evaluates the negative sequence of the phase currents. The thermal processes are taken into account in the algorithm and form the inverse characteristic. In addition, the negative sequence is evaluated by an independent stage (alarm and trip) which is supplemented by a time-delay element (see Figure 11/39). In the case of motors, the protection function is also used to monitor a phase failure.

Available inverse-time characteristics

Characteristics	ANSI	IEC 60255-3
Inverse	•	•
Moderately inverse	•	
Very inverse	•	•
Extremely inverse	•	•
Definite inverse	•	

Table 11/4

Underexcitation protection (Loss-of-field protection) (ANSI 40)

Derived from the generator terminal voltage and current, the complex admittance is calculated and corresponds to the generator diagram scaled in per unit. This protection prevents damage due to loss of synchronism resulting from underexcitation. The protection function provides three characteristics for monitoring static and dynamic stability. Via a transducer, the excitation voltage (see Figure 11/54) can be injected and, in the event of failure, a swift reaction of the protection function can be achieved by timer changeover.

The straight-line characteristics allow the protection to be optimally adapted to the generator diagram (see Figure 11/40). The per-unit-presentation of the diagram allows the setting values to be directly read out.

The positive-sequence systems of current and voltage are used to calculate the admittance. This ensures that the protection always operates correctly even with asymmetrical network conditions.

If the voltage deviates from the rated voltage, the admittance calculation has the advantage that the characteristics move in the same direction as the generator diagram.

11

Protection functions

Reverse-power protection (ANSI 32R)

The reverse-power protection monitors the direction of active power flow and picks up when the mechanical energy fails. This function can be used for operational shutdown (sequential tripping) of the generator but also prevents damage to the steam turbines. The reverse power is calculated from the positive-sequence systems of current and voltage. Asymmetrical power system faults therefore do not cause reduced measuring accuracy. The position of the emergency trip valve is injected as binary information and is used to switch between two trip command delays. When applied for motor protection, the sign (±) of the active power can be reversed via parameters.

Forward-power protection (ANSI 32F)

Monitoring of the active power produced by a generator can be useful for starting up and shutting down generators. One stage monitors exceeding of a limit value, while another stage monitors falling below another limit value. The power is calculated using the positive-sequence component of current and voltage. The function can be used to shut down idling motors.

Impedance protection (ANSI 21)

This fast short-circuit protection protects the generator and the unit transformer and is a backup protection for the power system. This protection has two settable impedance stages; in addition, the first stage can be switched over via binary input. With the circuit-breaker in the "open" position the impedance measuring range can be extended (see Figure 11/41).

The overcurrent pickup element with undervoltage seal-in ensures a reliable pickup and the loop selection logic ensures a reliable detection of the faulty loop. With this logic it is possible to perform correct measurement via the unit transformer.

Undervoltage protection (ANSI 27)

The undervoltage protection evaluates the positive-sequence components of the voltages and compares them with the threshold values. There are two stages available.

The undervoltage function is used for asynchronous motors and pumped-storage stations and prevents the voltage-related instability of such machines.

The function can also be used for monitoring purposes.

Overvoltage protection (ANSI 59)

This protection prevents insulation faults that result when the voltage is too high.

Either the maximum line-to-line voltages or the phase-to-earth voltages (for low-voltage generators) can be evaluated. The measuring results of the line-to-line voltages are independent of the neutral point displacement caused by earth faults. This function is implemented in two stages.

Frequency protection (ANSI 81)

The frequency protection prevents impermissible stress of the equipment (e.g. turbine) in case of under or overfrequency. It also serves as a monitoring and control element.

The function has four stages; the stages can be implemented either as underfrequency or overfrequency protection. Each stage can be delayed separately.

Even in the event of voltage distortion, the frequency measuring algorithm reliably identifies the fundamental waves and determines the frequency extremely precisely. Frequency measurement can be blocked by using an undervoltage stage.

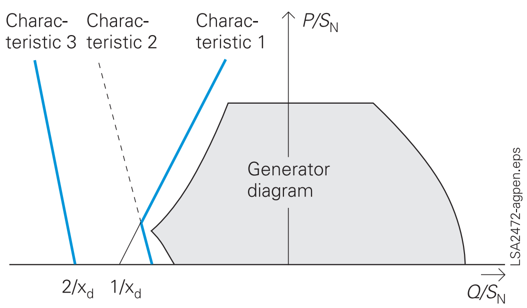


Fig. 11/40
Characteristic of underexcitation protection

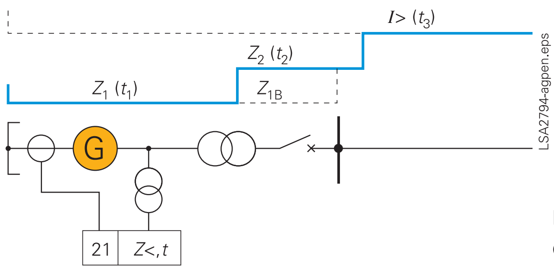


Fig. 11/41
Grading of impedance protection

Overexcitation protection Volt/Hertz (ANSI 24)

The overexcitation protection serves for detection of an unpermissible high induction (proportional to V/f) in generators or transformers, which leads to thermal overloading. This may occur when starting up, shutting down under full load, with weak systems or under isolated operation. The inverse characteristic can be set via eight points derived from the manufacturer data.

In addition, a definite-time alarm stage and an instantaneous stage can be used. For calculation of the V/f ratio, frequency and also the highest of the three line-to-line voltages are used. The frequency range that can be monitored comprises 11 to 69 Hz.

Protection functions

90 % stator earth-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)

Earth faults manifest themselves in generators that are operated in isolation by the occurence of a displacement voltage. In case of unit connections, the displacement voltage is an adequate, selective criterion for protection.

For the selective earth-fault detection, the direction of the flowing earth current has to be evaluated too, if there is a direct connection between generator and busbar.

The protection relay measures the displacement voltage at a VT located at the transformer star point or at the broken delta winding of a VT As an option, it is also possible to calculate the zero-sequence voltage from the phase-to-earth voltages.

Depending on the load resistor selection, 90 to 95 % of the stator winding of a generator can be protected.

A sensitive current input is available for earth-current measurement. This input should be connected to a core-balance current transformer. The fault direction is deduced from the displacement voltage and earth current. The directional characteristic (straight line) can be easily adapted to the system conditions. Effective protection for direct connection of a generator to a busbar can therefore be established. During start-up, it is possible to switch over from the directional to the displacement voltage measurement via an externally injected signal.

Depending on the protection setting, various earth-fault protection concepts can be implemented with this function (see Figures 11/52 to 11/55).

Sensitive earth-fault protection (ANSI 50/51GN, 64R)

The sensitive earth-current input can also be used as separate earth-fault protection. It is of two-stage form. Secondary earth currents of 2 mA or higher can be reliably handled.

Alternatively, this input is also suitable as rotor earth-fault protection. A voltage with rated frequency (50 or 60 Hz) is connected in the rotor circuit via the interface unit 7XR61. If a higher earth current is flowing, a rotor earth fault has occurred. Measuring circuit monitoring is provided for this application (see Figure 11/58).

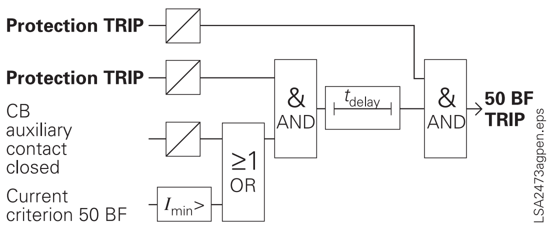


Fig. 11/42
Logic diagram of breaker failure protection

100 % stator earth-fault protection with 3rd harmonic (ANSI 59TN, 27TN (3rd H.))

Owing to the creative design, the generator produces a 3rd harmonic that forms a zero phase-sequence system. It is verifiable by the protection on a broken delta winding or on the neutral transformer. The magnitude of the voltage amplitude depends on the generator and its operation.

In the event of an earth fault in the vicinity of the neutral point, there is a change in the amplitude of the 3rd harmonic voltage (dropping in the neutral point and rising at the terminals).

Depending on the connection the protection must be set either as undervoltage or overvoltage protection. It can also be delayed. So as to avoid overfunction, the active power and the positive-sequence voltage act as enabling criteria.

The picked-up threshold of the voltage stage is restrained by the active power. This increases sensitivity at low load.

The final protection setting can be made only by way of a primary test with the generator.

Breaker failure protection (ANSI 50BF)

In the event of scheduled downtimes or a fault in the generator, the generator can remain on line if the circuit-breaker is defective and could suffer substantial damage.

Breaker failure protection evaluates a minimum current and the circuit-breaker auxiliary contact. It can be started by internal protective tripping or externally via binary input. Two-channel activation avoids overfunction (see Figure 11/42).

Inadvertent energization protection (ANSI 50, 27)

This protection has the function of limiting the damage of the generator in the event of an unintentional switch-on of the circuit-breaker, whether the generator is standing still or rotating without being excited or synchronized. If the power system voltage is connected, the generator starts as an asynchronous machine with a large slip and this leads to excessively high currents in the rotor.

A logic circuit consisting of sensitive current measurement for each phase, measured value detector, time control and blocking as of a minimum voltage, leads to an instantaneous trip command. If the fuse failure monitor responds, this function is ineffective.

Rotor earth-fault protection (ANSI 64R)

This protection function can be realized in three ways with the 7UM62. The simplest form is the method of rotor-current measurement (see sensitive earth-current measurement).

<u>Resistance measurement at system-frequency voltage</u>

The second form is rotor earth resistance measurement with voltage at system frequency (see Fig. 11/58). This protection measures the voltage injected and the flowing rotor earth current. Taking into account the complex impedance from the coupling device (7XR61), the rotor earth resistance is calculated by way of a mathematical model. By means of this method, the disturbing influence of the rotor earth capacitance is eliminated, and sensitivity is increased. Fault resistance values up to 30 kΩ can be measured if the excitation voltage is without disturbances. Thus, a two-stage protection function, which features a warning and a tripping stage, can be realized. An additionally implemented undercurrent stage monitors the rotor circuit for open circuit and issues an alarm.

Protection functions

Resistance measurement with a square wave voltage of 1 to 3 Hz

A higher sensitivity is required for larger generators. On the one hand, the disturbing influence of the rotor earth capacitance must be eliminated more effectively and, on the other hand, the noise ratio with respect to the harmonics (e.g. sixth harmonic) of the excitation equipment must be increased. Injecting a low-frequency square wave voltage into the rotor circuit has proven itself excellently here (see Figure 11/59).

The square wave voltage injected through the controlling unit 7XT71 leads to permanent recharging of the rotor earth capacitance. By way of a shunt in the controlling unit, the flowing earth current is measured and is injected into the protection unit (measurement input). In the absence of a fault ($R_E \approx \infty$), the rotor earth current after charging of the earth capacitance is close to zero. In the event of an earth fault, the fault resistance including the coupling resistance (7XR6004), and also the injecting voltage, defines the stationary current. The current square wave voltage and the frequency are measured via the second input (control input). Fault resistance values up to 80 kΩ can be measured by this measurement principle. The rotor earth circuit is monitored for discontinuities by evaluation of the current during the polarity reversals.

100% stator earth-fault protection with 20 Hz injection (ANSI 64 G (100%))

Injecting a 20 Hz voltage to detect earth faults even at the neutral point of generators has proven to be a safe and reliable method. Contrary to the third harmonic criterion (see page 11/8), it is independent of the generator's characteristics and the mode of operation. Measurement is also possible during system standstill (Fig. 11/57).

This protection function is designed so as to detect both earth faults in the entire generator (genuine 100 %) and all electrically connected system components.

The protection unit measures the injected 20 Hz voltage and the flowing 20 Hz current. The disturbing variables, for example stator earth capacitance, are eliminated by way of a mathematical model, and the ohmic fault resistance is determined.

On the one hand, this ensures high sensitivity and, on the other hand, it permits use of generators with large earth capacitance values, e.g. large hydroelectric generators.

Phase-angle errors through the earthing or neutral transformer are measured during commissioning and are corrected in the algorithm.

The protection function has a warning and tripping stage. The measurement circuit is also monitored and failure of the 20 Hz generator is measured.

Independent of earth resistance calculation, the protection function additionally evaluates the amount of the r.m.s. current value.

Starting time supervision (motor protection only) (ANSI 48)

Starting time supervision protects the motor against long unwanted start-ups, which might occur as a result of excessive load torque or excessive voltage drops within the motor, or if the rotor is locked.

The tripping time is dependent on the square of the start-up current and the set start-up time (Inverse Characteristic). It adapts itself to the start-up with reduced voltage. The tripping time is determined in accordance with the following formula:

$$t_{\text{Trip}} = \left(\frac{I_{\text{start}}}{I_{\text{rms}}}\right)^2 \cdot t_{\text{start max}}$$

t_{Trip}	Tripping time
I_{start}	Permissible start-up current
$t_{\text{start max}}$	Permissible start-up time
I_{rms}	Measured r.m.s. current value

Calculation is not started until the current I_{rms} is higher than an adjustable response value (e.g. 2 $I_{\text{N, MOTOR}}$).

If the permissible locked-rotor time is less than the permissible start-up time (motors with a thermally critical rotor), a binary signal is set to detect a locked rotor by means of a tachometer generator. This binary signal releases the set locked-rotor time, and tripping occurs after it has elapsed.

DC voltage time protection/DC current time protection (ANSI 59N (DC) 51N (DC))

Hydroelectric generators or gas turbines are started by way of frequency starting converters. An earth fault in the intermediate circuit of the frequency starting converter causes DC voltage displacement and thus a direct current. As the neutral or earthing transformers have a lower ohmic resistance than the voltage transformers, the largest part of the direct current flows through them, thus posing a risk of destruction from thermal overloading.

As shown in Fig. 11/57, the direct current is measured by means of a shunt transformer (measuring transducer) connected directly to the shunt. Voltages or currents are fed to the 7UM62 depending on the version of the measuring transducer. The measurement algorithm filters out the DC component and takes the threshold value decision. The protection function is active as from 0 Hz.

If the measuring transducer transmits a voltage for protection, the connection must be interference-free and must be kept short.

The implemented function can also be used for special applications. Thus, the r.m.s. value can be evaluated for the quantity applied at the input over a wide frequency range.

Overcurrent protection during start-up (ANSI 51)

Gas turbines are started by means of frequency starting converters. Overcurrent protection during start-up measures short-circuits in the lower frequency level (as from about 5 Hz) and is designed as independent overcurrent-time protection. The pickup value is set below the rated current. The function is only active during start-up. If frequencies are higher than 10 Hz, sampling frequency correction takes effect and the further short-circuit protection functions are active.

Out-of-step protection (ANSI 78)

This protection function serves to measure power swings in the system. If generators feed to a system short-circuit for too long, low frequency transient phenomena (active power swings) between the system and the generator may occur after fault clearing. If the center of power swing is in the area of the block unit, the "active power surges" lead to unpermissible mechanical stressing of the generator and the turbine.

As the currents and voltages are symmetrical, the positive-sequence impedance is calculated on the basis of their positive-sequence components and the impedance trajectory is evaluated. Symmetry is also monitored by evaluation of the negative-phase-sequence current. Two characteristics in the R/X diagram describe the active range (generator, unit transformer or power system) of the out-of-step protection. The associated counters are incremented depending on the range of the characteristic in which the impedance vector enters or departs. Tripping occurs when the set counter value is reached.

11

Protection functions

The counters are automatically reset if power swing no longer occurs after a set time. By means of an adjustable pulse, every power swing can be signaled. Expansion of the characteristic in the R direction defines the power swing angle that can be measured. An angle of 120 ° is practicable. The characteristic can be tilted over an adjustable angle to adapt to the conditions prevailing when several parallel generators feed into the system.

Inverse undervoltage protection (ANSI 27)

Motors tend to fall out of step when their torque is less than the breakdown torque. This, in turn, depends on the voltage. On the one hand, it is desirable to keep the motors connected to the system for as long as possible while, on the other hand, the torque should not fall below the breakdown level. This protection task is realized by inverse undervoltage protection. The inverse characteristic is started if the voltage is less than the pickup threshold V_p<. The tripping time is inversely proportional to the voltage dip (see equation). The protection function uses the positive-sequence voltage, for the protection decision.

$$t_{\mathrm{TRIP}} = \frac{I}{I - \dfrac{V}{V_p}} \cdot T_M$$

t_{TRIP}	Tripping time
V	Voltage
V_p	Pickup value
T_M	Time multiplier

System disconnection

Take the case of in-plant generators feeding directly into a system. The incoming line is generally the legal entity boundary between the system owner and the in-plant generator. If the incoming line fails as the result of auto-reclosure, for instance, a voltage or frequency deviation may occur depending on the power balance at the feeding generator. Asynchronous conditions may arise in the event of connection, which may lead to damage on the generator or the gearing between the generator and the turbine. Besides the classic criteria such as voltage and frequency, the following two criteria are also applied (vector jump, rate-of-frequency-change protection, see page 11/42).

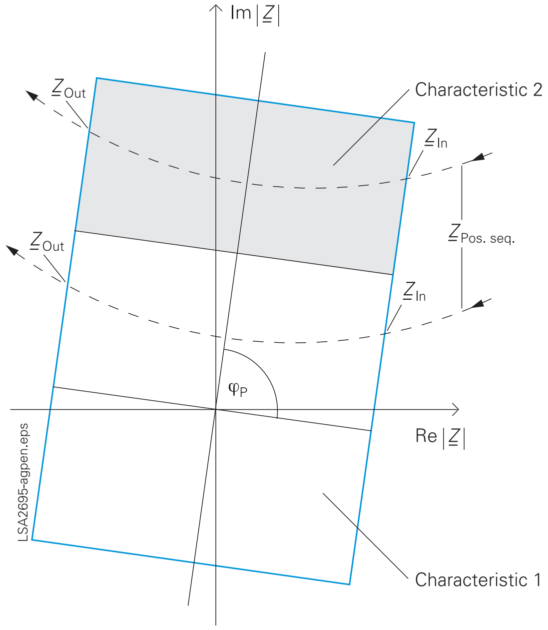


Fig. 11/43
Ranges of the characteristic and possible oscillation profiles.

Rate-of-frequency-change protection (ANSI 81)

The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed so that it reacts to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

Vector jump

Monitoring the phase angle in the voltage is a criterion for identifying an interrupted infeed. If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

Restart inhibit for motors (ANSI 66, 49Rotor)

When cold or at operating temperature, motors may only be connected a certain number of times in succession. The start-up current causes heat development in the rotor which is monitored by the restart inhibit function.

Contrary to classical counting methods, in the restart inhibit function the heat and cooling phenomena in the rotor are simulated by a thermal replica. The rotor temperature is determined on the basis of the stator currents. Restart inhibit permits restart of the motor only if the rotor has enough thermal reserve for a completely new start. Fig. 11/44 illustrates the thermal profile for a permissible triple start out of the cold state. If the thermal reserve is too low, the restart inhibit function issues a blocking signal with which the motor starting circuit can be blocked. The blockage is canceled again after cooling down and the thermal value has dropped below the pickup threshold.

As the fan provides no forced cooling when the motor is off, it cools down more slowly. Depending on the operating state, the protection function controls the cooling time constant. A value below a minimum current is an effective changeover criterion.

Sensitive earth-fault protection B (ANSI 51 GN)

The $I_{\mathrm{EE\text{-}B}}$ sensitive earth-fault protection feature of 7UM62 provides greater flexibility and can be used for the following applications:

- Any kind of earth-fault current supervision to detect earth faults (fundamental and 3rd harmonics)
- Protection against load resistances
- Shaft current protection in order to detect shaft currents of the generator shaft and prevent that bearings take damage.

Protection functions

The sensitive earth-current protection I_{EE-B} uses either the hardware input I_{EE1} or I_{EE2}. These inputs are designed in a way that allows them to cut off currents greater than 1.6 A (thermal limit, see technical data). This has to be considered for the applications or for the selection of the current transformers.

The shaft current protection function is of particular interest in conjunction with hydro-electric generators. Due to their construction, the hydroelectric generators have relatively long shafts. A number of factors such as friction, magnetic fields of the generators and others can build up a voltage across the shaft which then acts as voltage source (electro-motive force-emf). This inducted voltage of approx. 10 to 30 V is dependent on the load, the system and the machine.

If the oil film covering a bearing is too thin, breakdown can occur. Due to the low resistance (shaft, bearing and earthing), high currents may flow that destroy the bearing. Past experience has shown that currents greater than 1 A are critical for the bearings. As different bearings can be affected, the current entering the shaft is detected by means of a special transformer (folding transformer).

Interturn protection (ANSI 59N (IT))

The interturn fault protection detects faults between turns within a generator winding (phase). This situation may involve relatively high circulating currents that flow in the short-circuited turns and damage the winding and the stator. The protection function is characterized by a high sensitivity.

The displacement voltage is measured at the open delta winding by means of 3 two-phase isolated voltage transformers. So as to be insensitive towards earth faults, the isolated voltage transformer star point has to be connected to the generator star point by means of a high-voltage cable. The voltage transformer star point must not be earthed since this implies that the generator star point, too, would be earthed with the consequence that each fault would lead to a single-pole earth fault.

In the event of an interturn fault, the voltage in the affected phase will be reduced causing a displacement voltage that is detected at the broken delta winding. The sensitivity is limited rather by the winding asymmetries than by the protection unit.

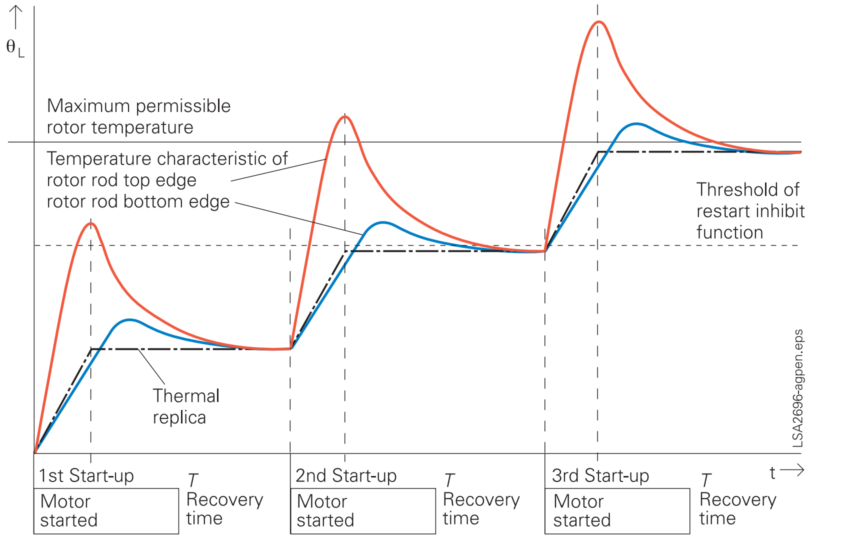


Fig. 11/44 Temperature characteristic at rotor and thermal replica of the rotor (multiple start-ups)

An FIR filter determines the fundamental component of the voltage based an the scanned displacement voltage. Selecting an appropriate window function has the effect that the sensitivity towards higher-frequency oscillations is improved and the disturbing influence of the third harmonic is eliminated while achieving the required measurement sensitivity.

External trip coupling

For recording and processing of external trip information, there are 4 binary inputs. They are provided for information from the Buchholz relay or generator-specific commands and act like a protection function. Each input initiates a fault event and can be individually delayed by a timer.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal occurs whenever the circuit is interrupted.

Phase rotation reversal

If the relay is used in a pumped-storage power plant, matching to the prevailing rotary field is possible via a binary input (generator/motor operation via phase rotation reversal).

2 pre-definable parameter groups

In the protection, the setting values can be stored in two data sets. In addition to the standard parameter group, the second group is provided for certain operating conditions (pumped-storage power stations). It can be activated via binary input, local control or DIGSI 4.

Lockout (ANSI 86)

All binary outputs (alarm or trip relays) can be stored like LEDs and reset using the LED reset key. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Fuse failure and other monitoring

The relay comprises high-performance monitoring for the hardware and software.

The measuring circuits, analog-digital conversion, power supply voltages, memories and software sequence (watch-dog) are all monitored.

The fuse failure function detects failure of the measuring voltage due to short-circuit or open circuit of the wiring or VT and avoids overfunction of the undervoltage elements in the protection functions.

The positive and negative-sequence system (voltage and current) are evaluated.

Filter time

All binary inputs can be subjected to a filter time (indication suppression).

Communication

With respect to communication, particular emphasis has been placed on high levels of flexibility, data integrity and utilization of standards common in energy automation. The design of the communication modules permits interchangeability on the one hand, and on the other hand provides openness for future standards (for example, Industrial Ethernet).

Local PC interface

The PC interface accessible from the front of the unit permits quick access to all parameters and fault event data. The use of the DIGSI 4 operating program during commissioning is particularly advantageous.

Rear-mounted interfaces

At the rear of the unit there is one fixed interface and two communication modules which incorporate optional equipment complements and permit retrofitting. They assure the ability to comply with the requirements of different communication interfaces (electrical or optical) and protocols (IEC 60870, PROFIBUS, DIGSI).

The interfaces make provision for the following applications:

Service interface (fixed)

In the RS485 version, several protection units can be centrally operated with DIGSI 4. By using a modem, remote control is possible. This provides advantages in fault clearance, in particular in unmanned substations.

System interface

This is used to communicate with a control or protection and control system and supports, depending on the module connected, a variety of communication protocols and interface designs. Furthermore, the units can exchange data through this interface via Ethernet and IEC 61850 protocol and can also be operated by DIGSI.

IEC 61850 protocol

As of mid-2004, the Ethernet-based IEC 61850 protocol is the worldwide standard for protection and control systems used by power supply corporations. Siemens is of the first manufacturer to support this standard. By means of this protocol, information can also be exchanged directly between bay units so as to set up simple masterless systems for bay and system interlocking. Access to the units via the Ethernet bus will also be possible with DIGSI.

IEC 60870-5-103

IEC 60870-5-103 is an internationally standardized protocol for communication in the protected area.

IEC 60870-5-103 is supported by a number of protection unit manufacturers and is used worldwide.

The generator protection functions are stored in the manufacturer-specific, published part of the protocol.

PROFIBUS-DP

PROFIBUS is an internationally standardized communication system (EN 50170).

PROFIBUS is supported internationally by several hundred manufacturers and has to date been used in more than 1,000,000 applications all over the world.

With the PROFIBUS-DP, the protection can be directly connected to a SIMATIC S5/S7. The transferred data are fault data, measured values and information from or to the logic (CFC).

MODBUS RTU

MODBUS is also a widely utilized communication standard and is used in numerous automation solutions.

DNP 3.0

DNP 3.0 (Distributed Network Protocol version 3) is a messaging-based communication protocol. The SIPROTEC 4 units are fully Level 1 and Level 2 compliant with DNP 3.0. DNP 3.0 is supported by a number of protection device manufacturers.

Safe bus architecture

- RS485 bus
  With this data transmission via copper conductors, electromagnetic interference influences are largely eliminated by the use of twisted-pair conductor. Upon failure of a unit, the remaining system continues to operate without any faults.
- Fiber-optic double ring circuit
  The fiber-optic double ring circuit is immune to electromagnetic interference. Upon failure of a section between two units, the communication system continues to operate without disturbance.

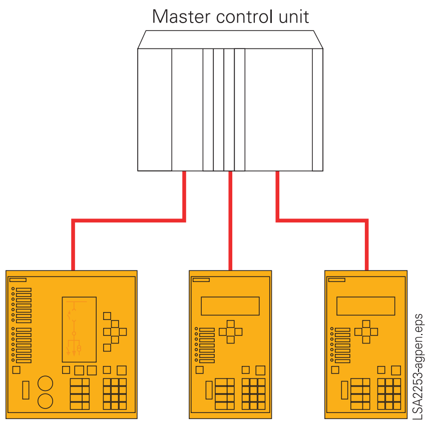


Fig. 11/45
IEC 60870-5-103 star-type RS232 copper conductor connection or fiber-optic connection

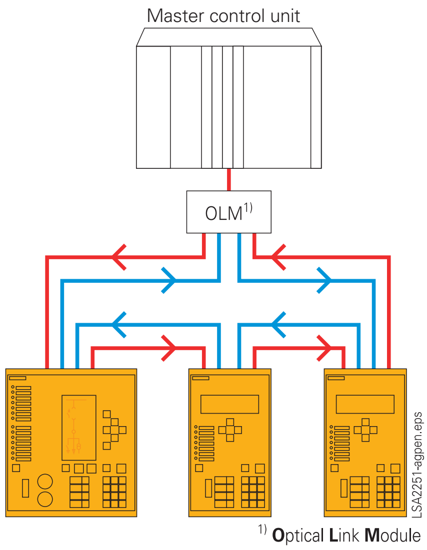


Fig. 11/46
PROFIBUS: Optical double ring circuit

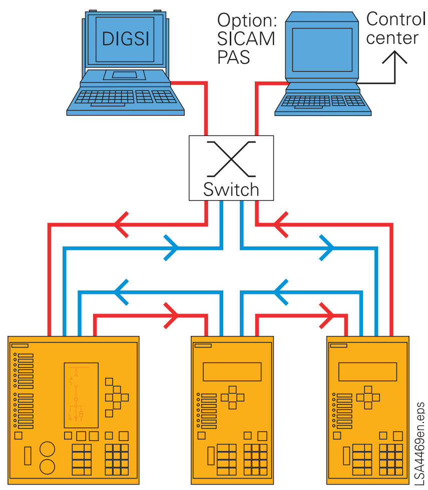


Fig. 11/47
Bus structure for station bus with Ethernet and IEC 61850, fiber-optic ring

Communication

System solution

SIPROTEC 4 is tailor-made for use in SIMATIC-based automation systems.

Via the PROFIBUS-DP, indications (pickup and tripping) and all relevant operational measured values are transmitted from the protection unit.

Via modem and service interface, the protection engineer has access to the protection devices at all times. This permits remote maintenance and diagnosis (cyclic testing).

Parallel to this, local communication is possible, for example, during a major inspection.

For IEC 61850, an interoperable system solution is offered with SICAM PAS. Via the 100 Mbit/s Ethernet bus, the unit are linked with PAS electrically or optically to the station PC. The interface is standardized, thus also enabling direct connection of units of other manufacturers to the Ethernet bus. With IEC 61850, however, the units can also be used in other manufacturers' systems (see Fig. 11/47).

Analog output 0 to 20 mA

Alternatively to the serial interfaces up to two analog output modules (4 channels) can be installed in the 7UM62.
Several operational measured values (I_1, I_2, V, P, Q, f, PF ($\cos\varphi$), Θ_{stator}, Θ_{rotor}) can be selected and transmitted via the 0 to 20 mA interfaces.

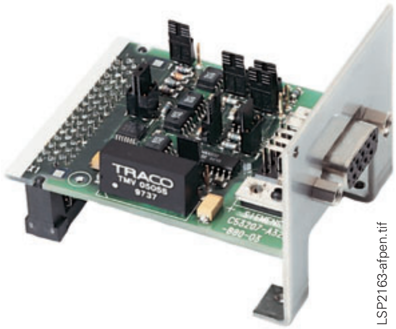


Fig. 11/48
RS232/RS485 electrical communication module

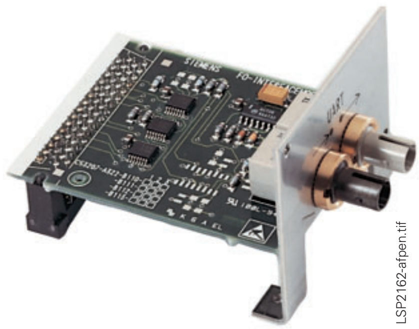


Fig. 11/49
Fiber-optic communication module

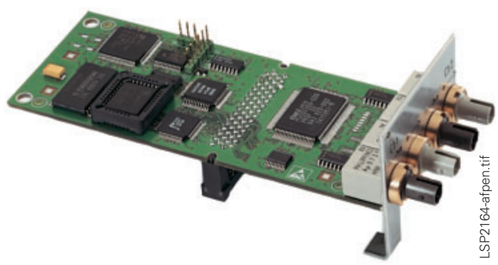


Fig. 11/50
Communication module, optical, double-ring

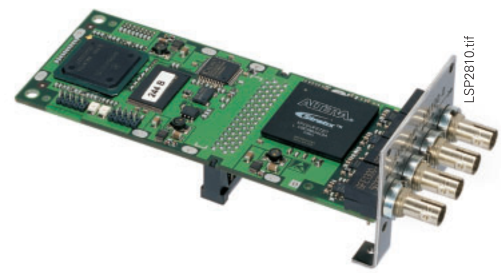


Fig. 11/51
Optical Ethernet communication module for IEC 61850 with integrated Ethernet switch

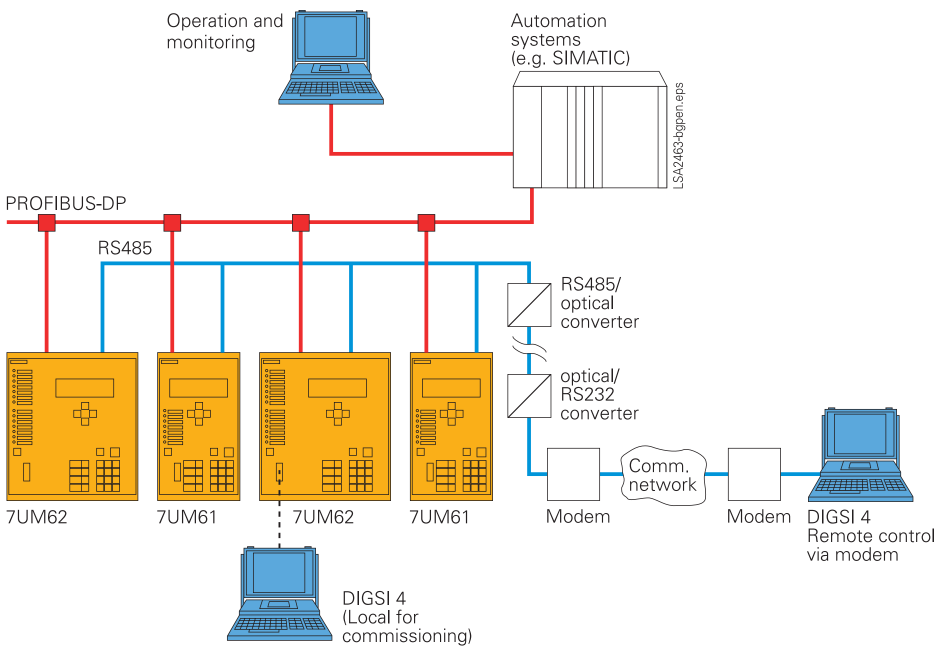


Fig. 11/52 System solution: Communications

Typical connections

Direct generator - busbar connection

Figure 11/53 illustrates the recommended standard connection when several generators supply one busbar. Phase-to-earth faults are disconnected by employing the directional earth-fault criterion. The earth-fault current is driven through the cables of the system.
If this is not sufficient, an earthing transformer connected to the busbar supplies the necessary current (maximum approximately 10 A) and permits a protection range of up to 90 %. The earth-fault current should be detected by means of core-balance current transformers in order to achieve the necessary sensitivity. The displacement voltage can be used as earth-fault criterion during starting operations until synchronization is achieved.

Differential protection embraces protection of the generator and of the outgoing cable. The permissible cable length and the current transformer design (permissible load) are mutually dependent. Recalculation is advisable for lengths of more than 100 m.

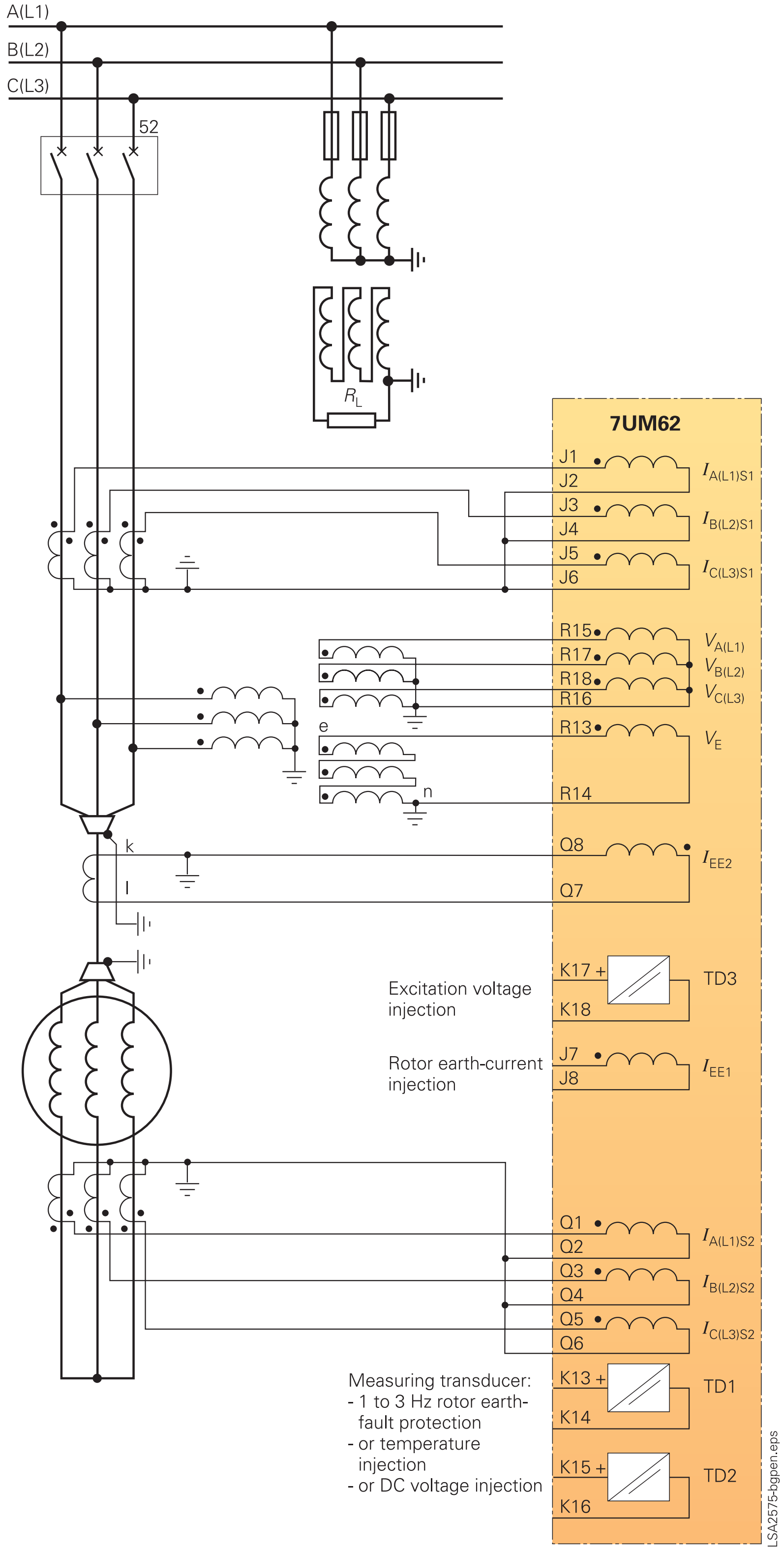


Fig. 11/53

Typical connections

Direct generator - busbar connection with low-resistance earthing

If the generator neutral point has low-resistance earthing, the connection illustrated in Fig. 11/54 is recommended. In the case of several generators, the resistance must be connected to only one generator, in order to prevent circulating currents (3rd harmonic).

For selective earth-fault detection, the earth-current input should be looped into the common return conductor of the two current transformer sets (differential connection). The current transformers must be earthed at only one point. The displacement voltage V_E is utilized as an additional enabling criterion.

Balanced current transformers (calibration of windings) are desirable with this form of connection. In the case of higher generator power (for example, I_N approximately 2000 A), current transformers with a secondary rated current of 5 A are recommended.

Earth-current differential protection can be used as an alternative (not illustrated).

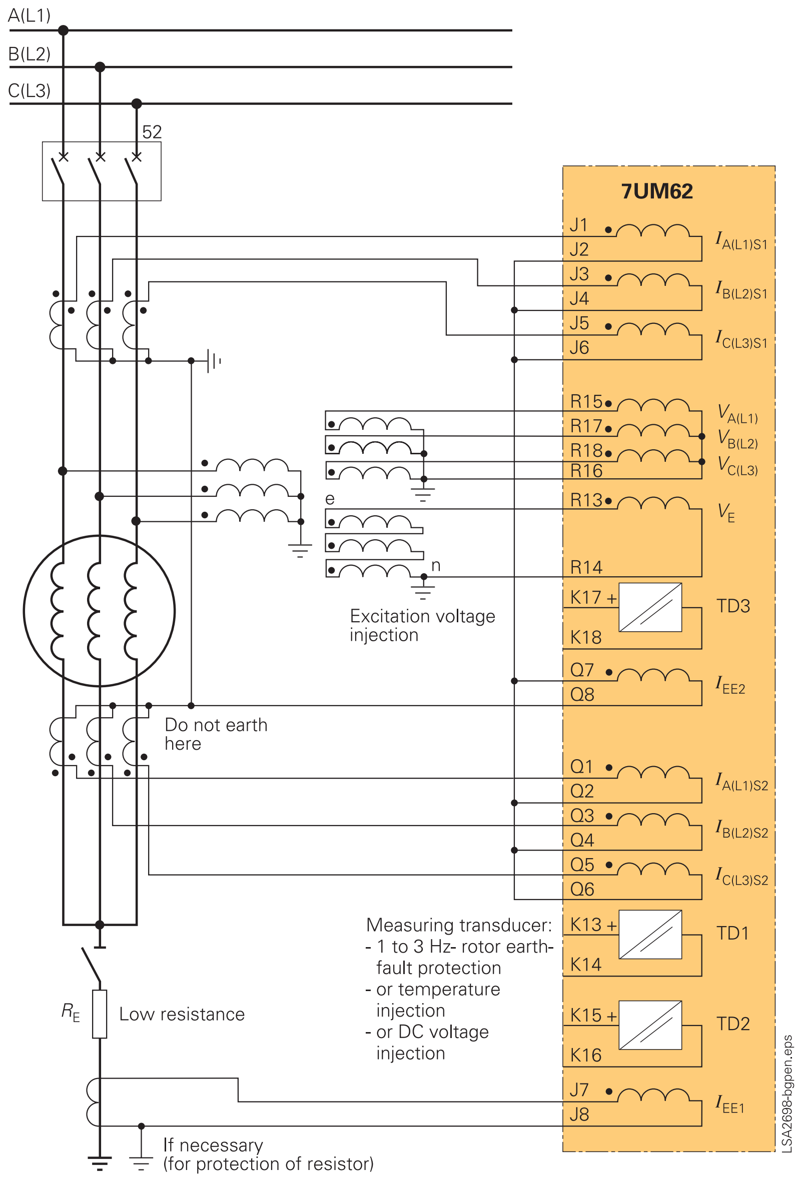


Fig. 11/54

Typical connections

Unit connection with isolated star point

This configuration of unit connection is a variant to be recommended (see Fig. 11/55). Earth-fault detection is effected by means of the displacement voltage. In order to prevent unwanted operation in the event of earth faults in the system, a load resistor must be provided at the broken delta winding. Depending on the plant (or substation), a voltage transformer with a high power (VA) may in fact be sufficient. If not, an earthing transformer should be employed. The available measuring winding can be used for the purpose of voltage measurement.

In the application example, differential protection is intended for the generator. The unit transformer is protected by its own differential relay (e.g. 7UT612).

As indicated in the figure, additional protection functions are available for the other inputs. They are used on larger generator/transformer units (see also Figures 11/58 and 11/60).

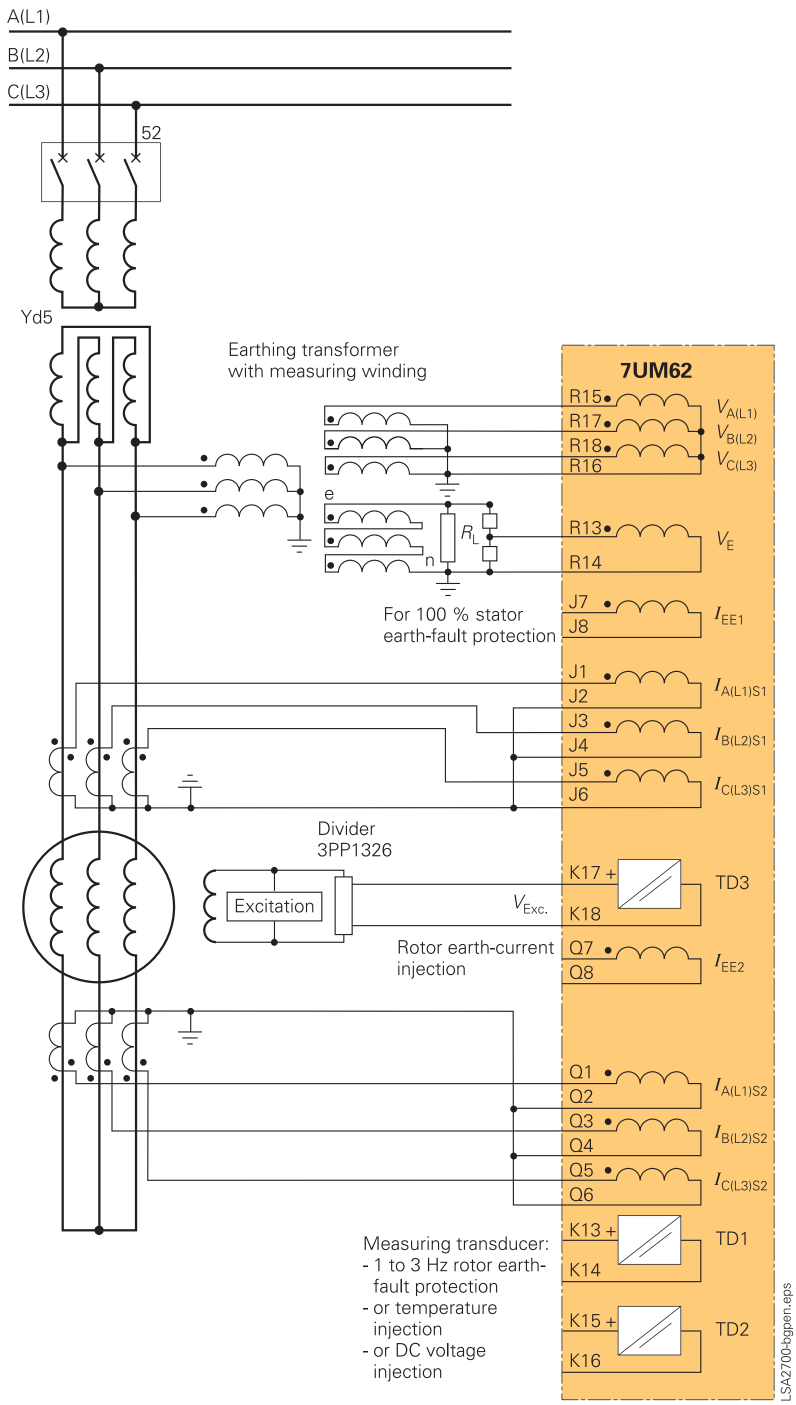


Fig. 11/55

11

Typical connections

Unit connection with neutral transformer

With this system configuration, disturbance voltage reduction and damping in the event of earth faults in the generator area are effected by a load resistor connected to the generator neutral point.

The maximum earth-fault current is limited to approximately 10 A. Configuration can take the form of a primary or secondary resistor with neutral transformer. In order to avoid low secondary resistance, the transformation ratio of the neutral transformer should be below

$$\left(\frac{V_{Gen}}{\sqrt{3}} \Big/ 500\,\text{V} \right)$$

The higher secondary voltage can be reduced by means of a voltage divider.

Electrically, the circuit is identical to the configuration in Fig. 11/55.

In the application opposite, the differential protection is designed as an overall function and embraces the generator and unit transformer. The protection function carries out vector group adaptation as well as other adaptations.

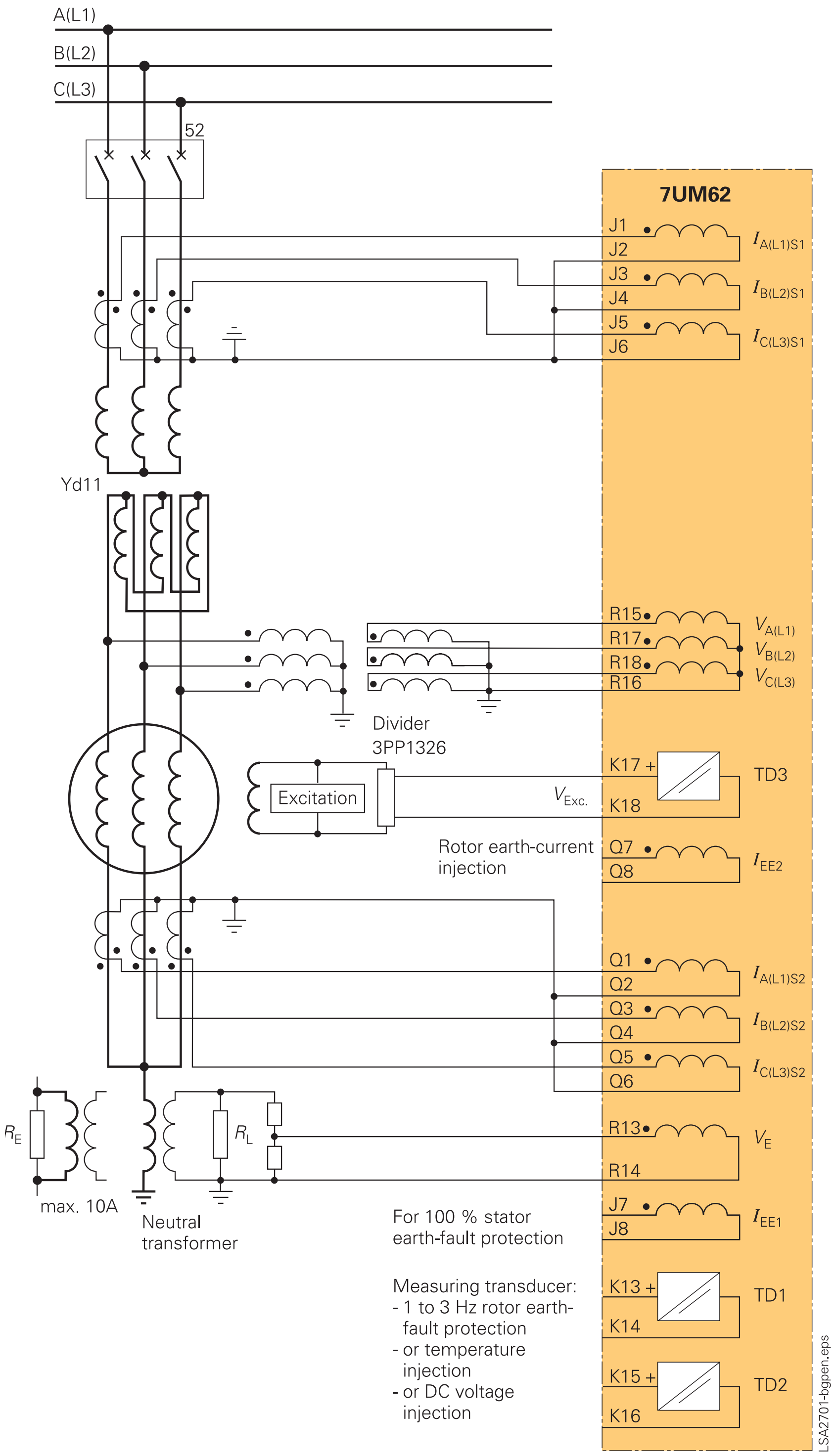


Fig. 11/56

Typical connections

Voltage transformer in open delta connection (V-connection)

Protection can also be implemented on voltage transformers in open delta connection (Fig. 11/57). If necessary, the operational measured values for the phase-to-earth voltages can be slightly asymmetrical. If this is disturbing, the neutral point (R16) can be connected to earth via a capacitor.

In the case of open delta connection, it is not possible to calculate the displacement voltage from the secondary voltages. It must be passed to the protection relay along a different path (for example, voltage transformer at the generator neutral point or from the earthing transformer).

100 % stator earth-fault protection, earth-fault protection during start-up

Fig. 11/58 illustrates the interfacing of 100 % stator earth-fault protection with voltage injection of 20 Hz, as meant for the example of the neutral transformer. The same interfacing connection also applies to the broken delta winding of the earthing transformer.

The 20 Hz generator can be connected both to the DC voltage and also to a powerful voltage transformer (>100 VA). The load of the current transformer 4NC1225 should not exceed 0.5 Ω.

The 7XT33, 7XT34 and load resistance connection must be established with a low resistance ($R_{\text{Connection}} < R_L$). If large distances are covered, the devices are accommodated in the earthing cubicle.

Connection of the DC voltage protection function (TD 1) is shown for systems with a starting converter. Depending on the device selection, the 7KG6 boosts the measured signal at the shunt to 10 V or 20 mA.

The TD 1 input can be jumpered to the relevant signal.

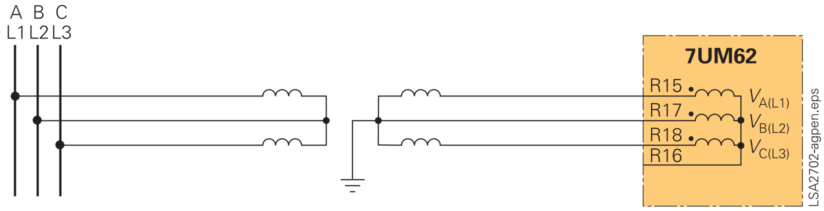


Fig. 11/57

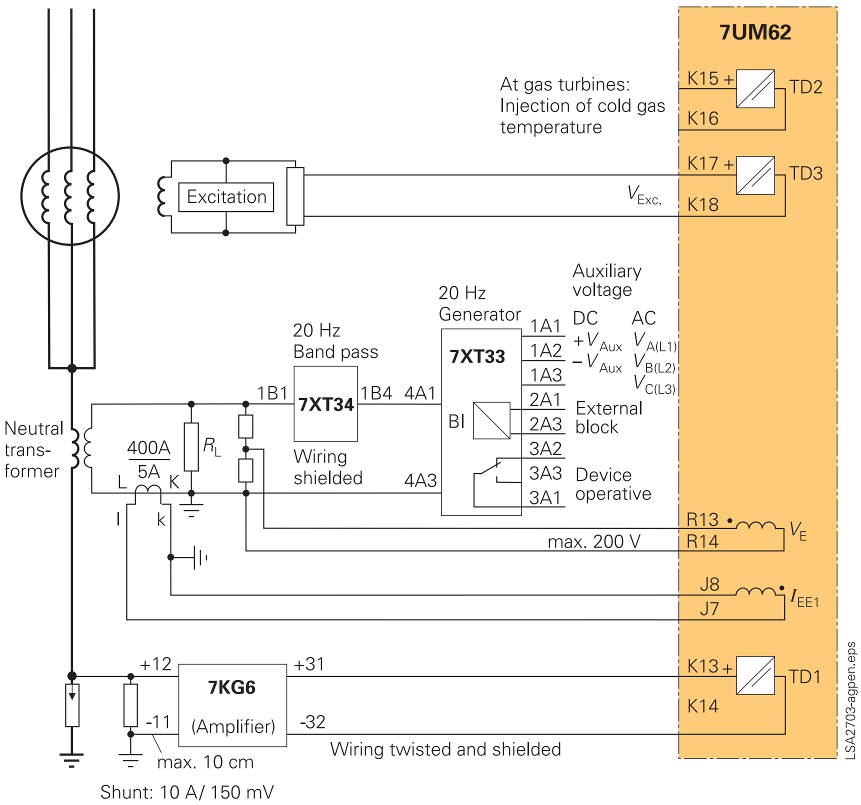


Fig. 11/58

Typical connections

Rotor earth-fault protection with voltage injection at rated frequency

Fig. 11/59 shows the connection of rotor earth-fault protection to a generator with static excitation. If only the rotor current is evaluated, there is no need for voltage connection to the relay.

Earth must be connected to the earthing brush. The external resistors 3PP1336 must be added to the coupling device 7XR61 if the circulating current can exceed 0.2 A as the result of excitation (sixth harmonic). This is the case as from a rated excitation voltage of >150 V, under worst-case conditions.

Rotor earth-fault protection with a square wave voltage of 1 to 3 Hz

The measuring transducers TD1 and TD2 are used for this application. The controlling unit 7XT71 generates a square wave voltage of about ± 50 V at the output. The frequency can be jumpered and depends on the rotor earth capacitance. Voltage polarity reversal is measured via the control input and the flowing circular current is measured via the measurement input. Earth must be connected to the earthing brush.

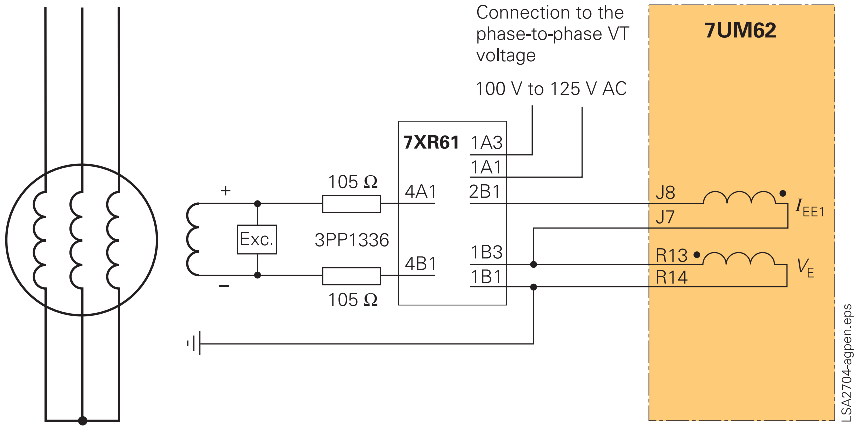


Fig. 11/59

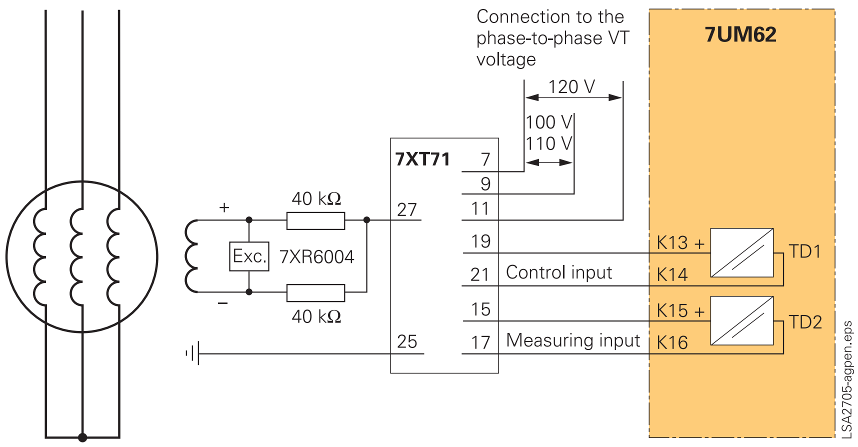


Fig. 11/60

Typical connections

Protection of an asynchronous motor

Fig. 11/61 shows a typical connection of the protection function to a large asynchronous motor. Differential protection embraces the motor including the cable. Recalculation of the permissible current transformer burden is advisable for lengths of more than 100 m.

The voltage for voltage and displacement voltage monitoring is generally tapped off the busbar. If several motors are connected to the busbar, earth faults can be detected with the directional earth-fault protection and selective tripping is possible. A core balance current transformer is used to detect the earth current. The chosen pickup value must be slightly higher if there are several cables in parallel.

The necessary shutdown of the motor in the event of idling can be realized with active power monitoring.

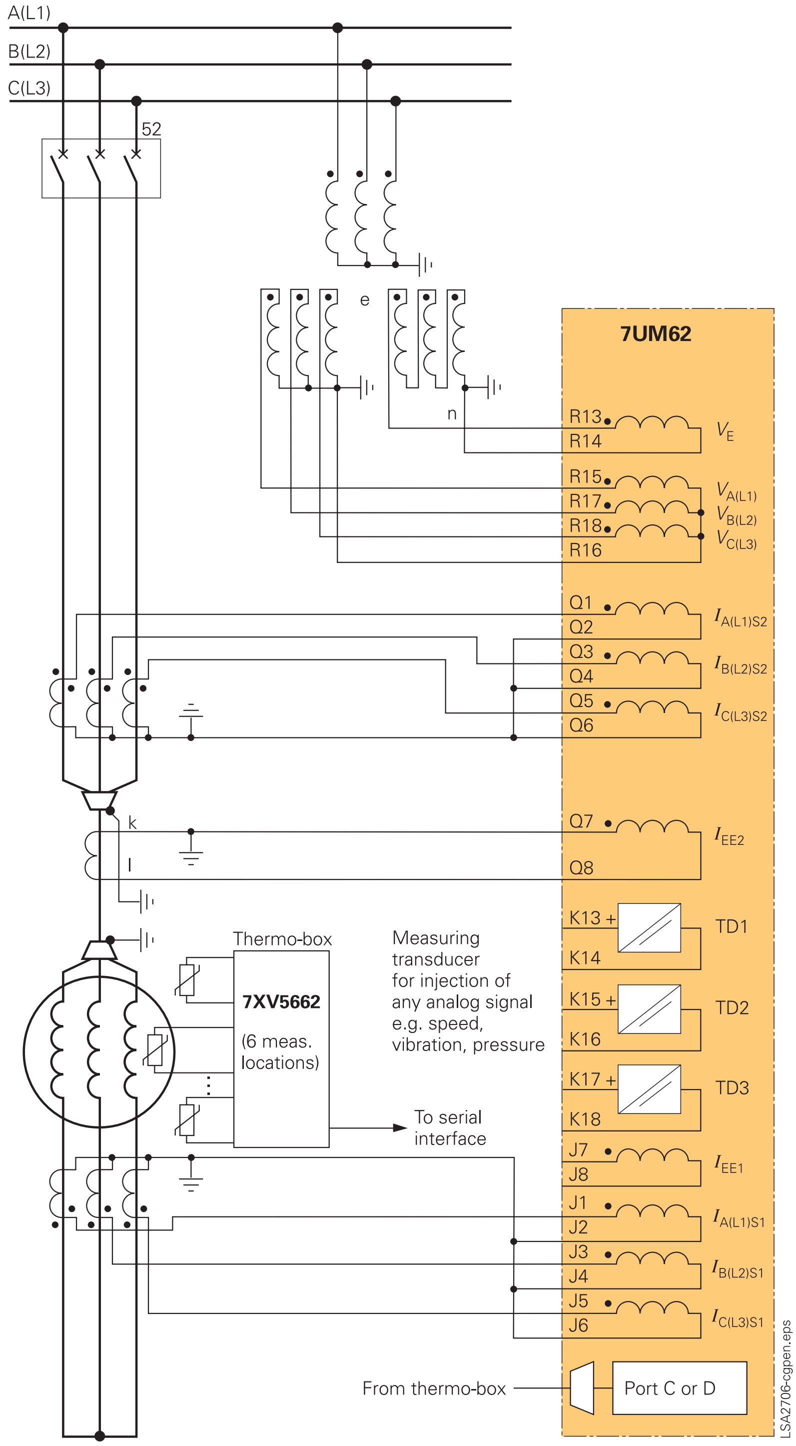


Fig. 11/61

Typical connections

Use of selected analog inputs

Several protection functions take recourse to the same analog inputs, thus ruling out certain functions depending on the application. One input may only be used by one protection function. A different combination can be used by the unit belonging to Protection Group 2, for example.

Multiple use refers to the sensitive earth-current inputs and the displacement voltage input (see Table 11/5).

The same applies to the measuring transducers (Table 11/6).

Current transformer requirements

The requirements imposed on the current transformer are determined by the differential protection function. The instantaneous trip stage (I_{Diff}>>) reliably masters (via the instantaneous algorithm) any high-current internal short-circuits.

The external short-circuit determines the requirements imposed on the current transformer as a result of the DC component. The non-saturated period of a flowing short-circuit current should be at least 5 ms. Table 11/7 shows the design recommendations.
IEC 60044-1 and 60044-6 were taken into account. The necessary equations are shown for converting the requirements into the knee-point voltages. The customary practice which presently applies should also be used to determine the rated primary current of the current transformer rated current. It should be greater than or equal to the rated current of the protected object.

	I_{EE1}	I_{EE2}	V_E
Sensitive earth-fault protection	X[1)]	X[1)]	
Directional stator earth-fault protection		X	X
Rotor earth-fault protection (f_n, R-measuring)	X		X
100 % stator earth-fault protection with 20 Hz voltage	X		X
Earth-current differential protection	X[1)]	X[1)]	

1) optional (either I_{EE1} or I_{EE2})

Table 11/5: Multiple use of analog inputs

	TD1	TD2	TD3
Injection of excitation voltage			X
DC voltage time/DC current time protection	X		
Injection of a temperature		X	
Rotor earth-fault protection (1 to 3 Hz)	X	X	
Processing of analog values via CFC	X	X	X

Table 11/6: Multiple use of measuring transducers

Symmetrical short-circuit limiting factor

Required actual accuracy limiting factor	Resulting rated accuracy limiting factor
$K'_{ssc} = K_{td} \cdot \frac{I_{pssc}}{I_{pn}}$	$K_{ssc} = \frac{R'_b + R_{Ct}}{R_{BN} + R_{Ct}} \cdot K'_{ssc}$

Current transformer requirements

	Transformer	Generator
Transient dimensioning factor K_{td}	≥ 4 $\tau_N \leq 100$ ms	$>$ (4 to 5) $\tau_N > 100$ ms
Symmetrical short-circuit current I_{pssc}	$\approx \frac{1}{v_{sc}} \cdot I_{pn, Tr}$	$\approx \frac{1}{x''_d} \cdot I_{pn, G}$
Example	$v_{sc} = 0.1$ $K'_{ssc} > 40$	$x''_d = 0.12$ $K'_{ssc} >$ (34 to 42)
Note: Identical transformers have to be employed	Rated power $\geq$ 10 or 15 VA Example: Network transformer 10P10: (10 or 15) VA (I_{sn} = 1 or 5 A)	Note: Secondary winding resistance Example: $I_{N,G}$ approx. 1000 to 2000 A 5P15: 15 VA (I_{sn} = 1 or 5 A) $I_{N,G} >$ 5 000 A 5P20: 30 VA (I_{sn} = 1 or 5 A)

Knee-point voltage

IEC	British Standard	ANSI
$V = K_{ssc}(R_{ct} + R_b)I_{sn}$	$V = \frac{(R_{ct} + R_b)I_{sn}}{1.3} K_{ssc}$	$V = 20 \cdot I_{sn} \cdot (R_{ct} + R_b) \cdot \frac{K_{ssc}}{20}$ I_{sn} = 5 A (typical value)

K_{td}	Rated transient dimensioning factor	R_{ct}	Secondary winding resistance
I_{pssc}	Primary symmetrical short-circuit current	v_{sc}	Short-circuit voltage (impedance voltage)
I_{pn}	Rated primary current (transformer)	x''_d	Subtransient reactance
R'_b	Connected burden	I_{sn}	Rated secondary current (transformer)
R_b	Rated resistive burden	τ_N	Network time constant

Table 11/7: Recommendations for dimensioning

11

Technical data

Hardware	
Analog input	
Rated frequency	50 or 60 Hz
Rated current I_N	1 or 5 A
Earth current, sensitive I_{Emax}	1.6 A
Rated voltage V_N (at 100 V)	100 to 125 V
Measuring transducer	- 10 to + 10 V (R_i = 1 MΩ) or - 20 to + 20 mA (R_i = 10 Ω)
Power consumption With I_N = 1 A With I_N = 5 A For sensitive earth current Voltage inputs (with 100 V)	 Approx. 0.05 VA Approx. 0.3 VA Approx. 0.05 VA Approx. 0.3 VA
Capability in CT circuits Thermal (r.m.s. values)	 100 I_N for 1 s 30 I_N for 10 s 4 I_N continuous
Dynamic (peak)	250 I_N (one half cycle)
Earth current, sensitive	300 A for 1 s 100 A for 10 s 15 A continuous
Dynamic (peak)	750 A (one half cycle)
Capability in voltage paths	230 V continuous
Capability of measuring transducer As voltage input As current input	 60 V continuous 100 mA continuous
Auxiliary voltage	
Rated auxiliary voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC and 115 V/230 V AC with 50/60 Hz
Permitted tolerance	–20 to +20 %
Superimposed (peak-to-peak)	≤ 15 %
Power consumption During normal operation 7UM621 7UM622 7UM623 During pickup with all inputs and outputs activated 7UM621 7UM622 7UM623	 Approx. 5.3 W Approx. 5.5 W Approx. 8.1 W Approx. 12 W Approx. 15 W Approx. 14.5 W
Bridging time during auxiliary voltage failure at V_{aux} = 48 V and V_{aux} ≥ 110 V at V_{aux} = 24 V and V_{aux} = 60 V	 ≥ 50 ms ≥ 20 ms
Binary inputs	
Number 7UM621, 7UM623 7UM622	 7 15
3 pickup thresholds Range is selectable with jumpers	10 to 19 V DC or 44 to 88 V DC 88 to 176 V DC
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA

Output relays	
Number 7UM621 7UM622	 12 (1 NO; 4 optional as NC, via jumper) 21 (1 NO; 5 optional as NC, via jumper)
Switching capacity Make Break Break (for resistive load) Break (for L/R ≤ 50 ms)	 1000 W / VA 30 VA 40 W 25 VA
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds
LED	
Number RUN (green) ERROR (red)	 1 1
Assignable LED (red)	14
Unit design	
7XP20 housing	For dimensions see dimension drawings, part 16
Degree of protection acc. to EN 60529 For surface-mounting housing For flush-mounting housing Front Rear For the terminals	 IP 51 IP 51 IP 50 IP 2x with terminal cover put on
Weight Flush-mounting housing 7UM621/7UM623 (1/2 x 19") 7UM622 (1/1 x 19") Surface-mounting housing 7UM621/7UM623 (1/2 x 19") 7UM622 (1/1 x 19")	 Approx. 7 kg Approx. 9.5 kg Approx. 12 kg Approx. 15 kg

Serial interfaces	
Operating interface for DIGSI 4	
Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector
Baud rate	4800 to 115200 baud
Time synchronization IRIG B / DCF 77 signal (Format: IRIG-B000)	
Connection	9-pin subminiature connector, terminal with surface-mounting case
Voltage levels	Selectable 5 V, 12 V or 24 V
Service/modem interface (Port C) for DIGSI 4 / modem / service	
Isolated RS232/RS485 Test voltage Distance for RS232 Distance for RS485	9-pin subminiature connector 500 V / 50 Hz Max. 15 m Max. 1000 m

Technical data

System interface (Port B) **IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU**	
Isolated RS232/RS485	9-pin subminiature connector
Baud rate	4800 to 115200 baud
Test voltage	500 V / 50 Hz
Distance for RS232	Max. 15 m
Distance for RS485	Max. 1000 m
PROFIBUS RS485	
Test voltage	500 V / 50 Hz
Baud rate	Max. 12 MBaud
Distance	1000 m at 93.75 kBaud; 100 m at 12 MBaud
PROFIBUS fiber-optic	
Only for flush-mounting housing	ST connector
For surface-mounting housing	Optical interface with OLM[1)]
Baud rate	Max. 1.5 MBaud
Optical wavelength	λ = 820 nm
Permissible path attenuation	Max. 8 dB for glass-fiber 62.5/125 µm
Distance	1.6 km (500 kB/s) 530 m (1500 kB/s)
Analog output module (electrical)	2 ports with 0 to 20 mA

System interface (Port B) **IEC 61850**	
Ethernet, electrical (EN 100) for IEC 61850 and DIGSI	
Connection	
for flush-mounting case	Rear panel, mounting location "B", two RJ45 connector, 100 Mbit/s acc. to IEEE802.3
for surface-mounting case	At bottom part of the housing
Test voltage	500 V; 50 Hz
Transmission speed	100 Mbits/s
Distance	20 m/66 ft
Ethernet, optical (EN 100) for IEC 61850 and DIGSI	
Connection	
for flush-mounting case	Rear panel, mounting location "B", ST connector receiver/transmitter
for panel surface-mounting case	Not available
Optical wavelength	λ = 1350 nm
Transmission speed	100 Mbits/s
Laser class 1 acc. to EN 60825-1/-2	Glass fiber 50/125 µm or glass fiber 62/125µm
Permissible path attenuation	Max. 5 dB for glass fiber 62.5/125µm
Distance	Max. 800 m/0.5 mile

Electrical tests

Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435, part 303 For further standards see below

Insulation tests	
Standards	IEC 60255-5
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs communication and time synchronization interfaces	2.5 kV (r.m.s.), 50/60 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	3.5 kV DC
Voltage test (100 % test) only isolated communication interfaces and time synchronization interface	500 V (r.m.s. value), 50/60 Hz

Insulation test *(cont'd)*	
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s

EMC tests for noise immunity; *type test*	
Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; τ = 15 ms 400 pulses per s; duration 2 s
Electrostatic discharge IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated, IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω, 9 µF Differential (transversal) mode: 1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	Common (longitudinal) mode: 2 kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; duration 2 s; R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω

1) Conversion with external OLM
For fiber-optic interface please complete order number at 11th position with 4 (FMS RS485) or 9 and Order code L0A (DP RS485) and additionally order:
For single ring: SIEMENS OLM 6GK1502-3AB10
For double ring: SIEMENS OLM 6GK1502-4AB10

11

Technical data

EMC tests for interference emission; type tests	
Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress test	
Temperatures	
Type-tested acc. to IEC 60068-2-1 and -2, test Bd, for 16 h	–25 °C to +85 °C / –13 °F to +185 °F
Temporarily permissible operating temperature, tested for 96 h	–20 °C to +70 °C / –4 °F to +158 °F
Recommended permanent operating temperature acc. to IEC 60255-6 (Legibility of display may be impaired above +55 °C / +131 °F)	–5 °C to +55 °C / +25 °F to +131 °F
– Limiting temperature during permanent storage	–25 °C to +55 °C / –13 °F to +131 °F
– Limiting temperature during transport	–25 °C to +70 °C / –13 °F to +158 °F

Climatic stress test *(cont'd)*	
Humidity	
Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation is not permitted

Functions	
General	
Frequency range	11 to 69 Hz
Definite-time overcurrent protection, directional *(ANSI 50, 51, 67)*	
Setting ranges	
Overcurrent $I>$, $I>>$	0.05 to 20 A (steps 0.01 A); 5 times at $I_N = 5$ A
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1 V)
Seal-in time of $V<$	0.1 to 60 s (steps 0.01 s)
Angle of the directional element (at $I>>$)	- 90 ° to + 90 ° (steps 1 °)
Times	
Pickup time $I>$, $I>>$	
at 2 times of set value	Approx. 35 ms
at 10 times of set value	Approx. 25 ms
Drop-off time $I>$, $I>>$	Approx. 50 ms
Drop-off ratio	$I>$: 0.95; $I>>$: 0.9 to 0.99 (steps 0.01)
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Current pickup (starting) $I>$, $I>>$	1 % of set value or 10/50 mA
Undervoltage seal-in $V<$	1 % of set value or 0.5 V
Angle of the directional element	1 °
Time delays	1 % or 10 ms
Inverse-time overcurrent protection *(ANSI 51V)*	
Setting ranges	
Pickup overcurrent I_P	0.1 to 4 A (steps 0.01 A); 5 times at $I_N = 5$A
Time multiplier IEC-characteristics T	0.05 to 3.2 s (steps 0,01 s) or indefinite
Time multiplier ANSI-characteristics D	0.5 to 15 (steps 0.01) or indefinite
Undervoltage release $V<$	10 to 125 V (steps 0.1 V)
Trip characteristics	
IEC	Normal inverse; very inverse; extremely inverse
ANSI	Inverse; moderately inverse; very inverse; extremely inverse; definite inverse
Pickup threshold	Approx. 1.1 I_P
Drop-off threshold	Approx. 1.05 I_P for $I_P/I_N \geq 0.3$
Tolerances	
Pickup threshold I_P	1 % of set value or 10/50 mA
Pickup threshold $V<$	1 % of set value or 0.5 V
Time for $2 \leq I/I_P \leq 20$	5 % of nominal value + 1 % current tolerance or 40 ms

11

Technical data

Stator overload protection, thermal (ANSI 49)	
Setting ranges	
Factor k according to IEC 60255-8	0.5 to 2.5 (steps 0.01)
Time constant	30 to 32000 s (steps 1 s)
Time delay factor at stand still	1 to 10 (steps 0.01)
Alarm overtemperature $\Theta_{Alarm}/\Theta_{Trip}$	70 to 100 % related to the trip temperature (steps 1 %)
Overcurrent alarm stage I_{Alarm}	0.1 to 4 A (steps 0.01 A); 5 times at I_N = 5 A
Temperature at I_N	40 to 200 °C (steps 1 °C) or 104 to 392 °F (steps 1 °F)
Scaling temperature of cooling medium	40 to 300 °C (steps 1 °C) or 104 to 572 °F (steps 1 °F)
Limit current I_{Limit}	0.5 to 8 A (steps 0.01), 5 times at I_N = 5 A
Reset time at emergency start	20 to 150000 s (steps 1 s)
Drop-off ratio	
Θ / Θ_{Trip}	Drop-off with Θ_{Alarm}
Θ / Θ_{Alarrm}	Approx. 0.99
I/I_{Alarm}	Approx. 0.95
Tolerances	
Regarding k x I_N	2 % or 10/50 mA; class 2 % according to IEC 60255-8
Regarding trip time	3 % or 1 s: class 3 % according to IEC 60255-8 for $I/(k\ I_N)$>1.25

Negative-sequence protection (ANSI 46)	
Setting ranges	
Permissible negative sequence $I_{2\ perm.}/I_N$	3 to 30 % (steps 1 %)
Definite time trip stage $I_2>>/I_N$	10 to 200 % (steps 1 %)
Time delays T_{Alarm}; T_{I2}>>	0 to 60 s (steps 0.01 s) or indefinite
Negative-sequence factor K	1 to 40 s (steps 0.1 s)
Cooling down time $T_{Cooling}$	0 to 50000 s (steps 1 s)
Times	
Pickup time (definite stage)	Approx. 50 ms
Drop-off time (definite stage)	Approx. 50 ms
Drop-off ratios $I_{2\ perm.}$; I_2>>	Approx. 0.95
Drop-off ratio thermal stage	Drop-off at fall below of $I_{2\ perm.}$
Tolerances	
Pickup values $I_{2\ perm.}$; I_2>>	3 % of set value or 0.3 % negative sequence
Time delays	1 % or 10 ms
Thermal characteristic	5 % of set point + 1 % current tolerance
Time for $2 \leq I_2/I_{2\ perm.} \leq 20$	or 600 ms

Underexcitation protection (ANSI 40)	
Setting ranges	
Conductance thresholds 1/xd characteristic (3 characteristics)	0.20 to 3.0 (steps 0.01)
Inclination angle $\alpha_1, \alpha_2, \alpha_3$	50 to 120 ° (steps 1 °)
Time delay T	0 to 50 s (steps 0.01 s) or indefinite
Undervoltage blocking V<	10 to 125 V (steps 0.1 V)
Times	
Stator criterion 1/xd characteristic; α	Approx. 60 ms
Undervoltage blocking	Approx. 50 ms
Drop-off ratio	
Stator criterion 1/xd characteristic; α	Approx. 0.95
Undervoltage blocking	Approx. 1.1
Tolerances	
Stator criterion 1/xd characteristic	3 % of set value
Stator criterion α	1 ° electrical
Undervoltage blocking	1 % or 0.5 V
Time delays T	1 % or 10 ms

Reverse-power protection (ANSI 32R)	
Setting ranges	
Reverse power $P_{Rev.}>/S_N$	- 0.5 to - 30 % (steps 0.01 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off ratio $P_{Rev.}$>	Approx. 0.6
Tolerances	
Reverse power $P_{Rev.}$>	0.25 % S_N ± 3 % set value
Time delays T	1 % or 10 ms

Forward-power protection (ANSI 32F)	
Setting ranges	
Forward power $P_{Forw.}</S_N$	0.5 to 120 % (steps 0.1 %)
Forward power $P_{Forw.}>/S_N$	1 to 120 % (steps 0.1 %)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Pickup time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off time (accurate measuring)	Approx. 360 ms (50 Hz); Approx. 300 ms (60 Hz)
Drop-off time (fast measuring)	Approx. 60 ms (50 Hz); Approx. 50 ms (60 Hz)
Drop-off ratio $P_{Forw.}$<	1.1 or 0.5 % of S_N
Drop-off ratio $P_{Forw.}$>	Approx. 0.9 or – 0.5 % of S_N
Tolerances	
Active power $P_{Forw.}$<, $P_{Forw.}$>	0.25 % S_N ± 3 % of set value at Q < 0.5 S_N at accurate measuring; 0.5 % S_N ± 3 % of set value at Q < 0.5 S_N at fast measuring
Time delays T	1 % or 10 ms

11

Technical data

Impedance protection (ANSI 21)	
Setting ranges	
Overcurrent pickup $I>$	0.1 to 20 A (steps 0.01 A); 5 times at I_N = 5A
Undervoltage seal-in $V<$	10 to 125 V (steps 0.1V)
Impedance Z1 (related to I_N =1 A)	0.05 to 130 Ω (steps 0.01 Ω)
Impedance Z1B (related to I_N =1 A)	0.05 to 65 Ω (steps 0.01 Ω)
Impedance Z2 (related to I_N =1 A)	0.05 to 65 Ω (steps 0.01 Ω)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Shortest tripping time	Approx. 40 ms
Drop-off time	Approx. 50 ms
Drop-off ratio	
Overcurrent pickup $I>$	Approx. 0.95
Undervoltage seal-in $V<$	Approx. 1.05
Tolerances	
Overcurrent pickup $I>$	1 % of set value or 10/50 mA
Undervoltage seal-in $V<$	1 % of set value or 0.5 V
Impedance measuring Z1, Z2	$\|\Delta Z/Z\| \leq 5\ \%$ for $30° \leq \varphi_K \leq 90°$
Time delays T	1 % or 10 ms

Undervoltage protection (definite-time and inverse-time function) (ANSI 27)	
Setting range	
Undervoltage pickup $V<$, $V<<$, $V_p<$ (positive sequence as phase-to-phase values)	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time multiplier T_M	0.1 to 5 s (steps 0.01 s)
Times	
Pickup time $V<$, $V<<$	Approx. 50 ms
Drop-off time $V<$, $V<<$	Approx. 50 ms
Drop-off ratio $V<$, $V<<$, $V_p<$	1.01 or 0.5 V
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms
Inverse-time characteristic	1 % of measured value of voltage

Overvoltage protection (ANSI 59)	
Setting ranges	
Overvoltage pickup $V>$, $V>>$ (maximum phase-to-phase voltage or phase-to-earth-voltage)	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times $V>$, $V>>$	Approx. 50 ms
Drop-off times $V>$, $V>>$	Approx. 50 ms
Drop-off ratio $V>$, $V>>$	0.9 to 0.99 (steps 0.01)
Tolerances	
Voltage limit value	1 % of set value 0.5 V
Time delays T	1 % or 10 ms

Frequency protection (ANSI 81)	
Setting ranges	
Steps; selectable $f>$, $f<$	4
Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Time delays T	3 stages 0 to 100 s, 1 stage up to 600 s (steps 0.01 s)
Undervoltage blocking $V_1<$	10 to 125 V (steps 0.1 V)
Times	
Pickup times $f>$, $f<$	Approx. 100 ms
Drop-off times $f>$, $f<$	Approx. 100 ms
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V_1<$	Approx. 1.05
Tolerances	
Frequency	10 mHz (at $V>$ 0.5 V_N)
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Overexcitation protection (Volt/Hertz) (ANSI 24)	
Setting ranges	
Pickup threshold alarm stage	1 to 1.2 (steps 0.01)
Pickup threshold $V/f>>$-stage	1 to 1.4 (steps 0.01)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Characteristic values of V/f	1.05/1.1/1.15/1.2/1.25/1.3/1.35/1.4
and assigned times t(V/f)	0 to 20000 s (steps 1 s)
Cooling down time $T_{Cooling}$	0 to 20000 s (steps 1 s)
Times (Alarm and $V/f>>$-stage)	
Pickup times at 1.1 of set value	Approx. 60 ms
Drop-off times	Approx. 60 ms
Drop-off ratio (alarm, trip)	0.95
Tolerances	
V/f-pickup	3 % of set value
Time delays T	1 % or 10 ms
Thermal characteristic (time)	5 % rated to V/f or 600 ms

90 % stator earth-fault protection, non-directional, directional (ANSI 59N, 64G, 67G)	
Setting ranges	
Displacement voltage V_0 >	2 to 125 V (steps 0.1 V)
Earth current $3I_0$>	2 to 1000 mA (steps 1 mA)
Angle of direction element	0 to 360 ° (steps 1 °)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times V_0>, $3I_0$>	Approx. 50 ms
Drop-off times V_0>/ $3I_0$>	Approx. 50 ms
Drop-off ratio V_0>, $3I_0$>	0.95
Drop-off difference angle	10 ° directed to power system
Tolerances	
Displacement voltage	1 % of set value or 0.5 V
Earth current	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms

11

Technical data

Sensitive earth-fault protection *(ANSI 50/51GN, 64R)*	
Setting ranges	
Earth current pickup $I_{EE}>$, $I_{EE}>>$	2 to 1000 mA (steps 1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Measuring circuit supervision $I_{EE}<$	1.5 to 50 mA (steps 0.1 mA)
Times	
Pickup times	Approx. 50 ms
Drop-off times	Approx. 50 ms
Measuring circuit supervision	Approx. 2 s
Drop-off ratio $I_{EE}>$, $I_{EE}>>$	0.95 or 1 mA
Drop-off ratio measuring circuit supervision $I_{EE}<$	Approx. 1.1 or 1 mA
Tolerances	
Earth current pickup	1 % of set value or 0.5 mA
Time delays T	1 % or 10 ms

100 % stator earth-fault protection with 3rd harmonic *(ANSI 59TN, 27TN) (3rd H.)*	
Setting ranges	
Displacement voltage $V_{0\,(3rd\ harm.)}>$, $V_{0\,(3rd\ harm.)}<$	0.2 to 40 V (steps 0.1 V)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Active-power release	10 to 100 % (steps 1 %) or indefinite
Positive-sequence voltage release	50 to 125 V (steps 0.1 V) or indefinite
Times	
Pickup time	Approx. 80 ms
Drop-off time	Approx. 80 ms
Drop-off ratio	
Undervoltage stage $V_{0\,(3rd\ harm.)}<$	Approx. 1.4
Overvoltage stage $V_{0\,(3rd\ harm.)}>$	Approx. 0.6
Active-power release	Approx. 0.9
Positive-sequence voltage release	Approx. 0.95
Tolerances	
Displacement voltage	3 % of set value or 0.1 V
Time delay T	1 % or 10 ms

Breaker failure protection *(ANSI 50BF)*	
Setting ranges	
Current thresholds I>BF	0.04 to 1 A (steps 0.01 A)
Time delay BF-T	0.06 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time	Approx. 50 ms
Drop-off time	Approx. 50 ms
Tolerances	
Current threshold I>BF/I_N	1 % of set value or 10/50 mA
Time delay T	1 % or 10 ms

Inadvertent energizing protection *(ANSI 50, 27)*	
Setting ranges	
Current pickup $I>>>$	0.1 to 20 A (steps 0.1 A); 5 times at I_N= 5 A
Voltage release $V_1<$	10 to 125 V (steps 1 V)
Time delay	0 to 60 s (steps 0.01 s) or indefinite
Drop-off time	0 to 60 s (steps 0.01 s) or indefinite
Times	
Reaction time	Approx. 25 ms
Drop-off time	Approx. 35 ms
Drop-off ratio $I>>>$	Approx. 0.8
Drop-off ratio $V_1<$	Approx. 1.05
Tolerances	
Current pickup	5 % of set value or 20/100 mA
Undervoltage seal-in $V_1<$	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

Current differential protection *(ANSI 87G, 87M, 87T)*	
Setting ranges	
Differential current $I_D>I_N$	0.05 to 2 (steps 0.01)
High-current stage $I_D>>I_N$	0.8 to 12 (steps 0.1)
Inrush stabilization ratio I_{2fN}/I_N	10 to 80 (steps 1 %)
Harmonic stabilization ratio I_{nfN}/I_N (n=3rd or 4th or 5th harmonics)	10 to 80 (steps 1 %)
Additional trip time delay T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time ($I_D \geq$ 1.5 setting value I_D >)	Approx. 35 ms
Pickup time ($I_D \geq$ 1.5 setting value I_D>>)	Approx. 20 ms
Drop-off time	Approx. 35 ms
Drop-off ratio	Approx. 0.7
Tolerances	
Pickup characteristic	3 % of set value or 0.01 I/I_N
Inrush stabilization	3 % of set value or 0.01 I/I_N
Additional time delays	1 % or 10 ms

Earth-current differential protection *(ANSI 87GN, 87TN)*	
Setting ranges	
Differential current $I_{E\text{-}D}$ >/I_N	0.01 to 1 (steps 0.01)
Additional trip time delay	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time ($I_{E\text{-}D} \geq$ 1.5 setting value $I_{E\text{-}D}$ >)	Approx. 50 ms
Drop-off time	Approx. 50 ms
Drop-off ratio	Approx. 0.7
Tolerances	
Pickup characteristic	3 % of set value
Additional time delay	1 % or 10 ms

11

Technical data

Rotor earth-fault protection with f_N (ANSI 64R) (f_N)

Setting ranges	
Alarm stage $R_{E, Alarrn}$ <	3 to 30 kΩ (steps 1 kΩ)
Trip stage $R_{E, Trip}$ <	1.0 to 5 kΩ (steps 0.1 kΩ)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Correction angle	- 15 ° to + 15 ° (steps 1 °)
Times	
Pickup time	≤ 80 ms
Drop-off time	≤ 80 ms
Drop-off ratio	Approx. 1.25
Tolerances	
Trip stage $R_{E, Trip}$ <,	Approx. 5 % of set value
Alarm stage $R_{E, Alarm}$ <	Approx. 10 % of set value
Time delays T	1 % or 10 ms
Permissible rotor earth capacitance	0.15 to 3 µF

Sensitive rotor fault protection with 1 to 3 Hz (ANSI 64R) (1 to 3 Hz)

Setting ranges	
Alarm stage $R_{E,Alarrn}$ <	5 to 80 kΩ (steps 1 kΩ)
Trip stage $R_{E, Trip}$ <	1 to 10 kΩ (steps 1 kΩ)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Pickup value of meas. circuit supervision Q_C<	0.01 to 1 mAs (steps 0.01 mAs)
Times	
Pickup time	Approx. 1 to 1.5 s (depends on frequency of 7XT71)
Drop-off time	Approx. 1 to 1.5 s
Drop-off ratio R_E	Approx 1.25
Drop-off ratio Q_C <	1.2 or 0.01 mAs
Tolerances	
Trip stage ($R_{E,Trip}$ <; Alarm stage $R_{E, Alarm}$<)	Approx. 5 % or 0.5 kΩ at 0.15 µF ≤ C_E < 1µF Approx. 10 % or 0.5 kΩ at 1 µF ≤ C_E < 3 µF
Time delays T	1 % or 10 ms
Permissible rotor earth-capacitance	0.15 to 3 µF

100 % stator earth-fault protection with 20 Hz (ANSI 64G) (100 %)

Setting ranges	
Alarm stage R_{SEF} <	20 to 500 Ω (steps 1 Ω)
Trip stage R_{SEF} <<	10 to 300 Ω (steps 1 Ω)
Earth current stage I_{SEF} >	0.02 to 1.5 A (steps 0.01 A)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Supervision of 20 Hz generator	
$V_{20\,Hz}$	0.3 to 15 V (steps 0.1 V)
$I_{20\,Hz}$	5 to 40 mA (steps 1 mA)
Correction angle	- 60 ° to + 60 ° (steps 1 °)
Times	
Pickup times R_{SEF}<, R_{SEF}<<	≤ 1.3 s
Pickup time I_{SEF}>	≤ 250 ms
Drop-off times R_{SEF}<, R_{SEF}<<	≤ 0.8 s
Drop-off time I_{SEF}>	≤ 120 ms
Drop-off ratio	Approx. 1.2 to 1.7
Tolerances	
Resistance (R_{SEF})	ca. 5 % or 2 Ω
Earth current stage (I_{SEF} >)	3 % or 3 mA
Time delays T	1 % or 10 ms

Out-of-step protection (ANSI 78)

Setting ranges	
Positive sequence current pickup I_1>	0.2 to 4 I_1/I_N (steps 0.1 I_1/I_N)
Negative-sequence current pickup I_2<	0.05 to 1 I_2/I_N (steps 0.01 I_2/I_N)
Impedances Z_a to Z_d (based on I_N =1 A)	0.05 to 130 Ω (steps 0.01 Ω)
Inclination angle of polygon φ_P	60 to 90 ° (steps 1 °)
Number of out-of-step periods characteristic 1	1 to 10
Number of out-of-step periods characteristic 2	1 to 20
Holding time of pickup t_H	0.2 to 60 s (steps 0.01 s)
Holding time for out-of-step annunciation	0.02 to 0.15 s (steps 0.01 s)
Times	
Typical trip time	Depending from the out-of-step frequency
Tolerances	
Impedance measurement	$\|\Delta Z/Z\|$ ≤ 5 % for 30 ° ≤ φ_{SC} ≤ 90 ° or 10 mΩ
Time delays T	1 % to 10 ms

DC voltage time / DC current time protection (ANSI 59N (DC) ; 51N (DC))

Setting ranges	
Voltage pickup V = >,<	0.1 to 8.5 V (steps 0.1 V)
Current pickup I = >, <	0.2 to 17 mA (steps 0.1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup time (operational condition 1)	Approx. 60 ms
Pickup time (operational condition 0)	Approx. 200 ms
Drop-off time	Approx. 60 ms or 200 ms
Drop-off ratio	0.9 or 1.1
Tolerances	
Voltage	1 % of set value, or 0.1 V
Current	1 % of set value, or 0.1 mA
Time delays T	1 % or 10 ms

Starting time supervision for motors (ANSI 48)

Setting ranges	
Motor starting current $I_{Start\,max}$ /I_N	1.0 to 16 (steps 0.01)
Starting current pickup $I_{Start,\,pickup.}$ /I_N	0.6 to 10 (steps 0.01)
Permissible starting time $T_{Start\,max}$	1.0 to 180 s (steps 0.1 s)
Permissible locked rotor time $T_{Blocking}$	0.5 to 120 s (steps 0.1 s) or indefinite
Times	Depending on the settings
Drop-off ratio	Approx. 0.95
Tolerances	
Current threshold	1 % of set value, or 1 % of I_N
Time delays T	5 % or 30 ms

Technical data

Restart inhibit for motors (ANSI 66, 49 Rotor)	
Setting ranges	
Motor starting current $I_{Start\ max}$ / I_N	3.0 to 10.0 (steps 0.01)
Permissible starting time $T_{Start\ max}$	3.0 to 120.0 s (steps 0.1 s)
Rotor temperature equalization time $T_{Equali.}$	0 to 60.0 min (steps 0.1 min)
Minimum restart inhibit time $T_{Restart,\ min}$	0.2 to 120.0 min (steps 0.1 min)
Permissible number of warm starts n_W	1 to 4
Difference between warm and cold starts n_K-n_W	1 to 2
Extensions of time constants (running and stop)	1.0 to 100.0
Tolerances	
Time delays T	1 % or 0.1 ms

Rate-of-frequency-change protection (ANSI 81R)	
Setting ranges	
Steps, selectable +df/dt >; - df/dt	4
Pickup value df/dt	0.2 to 10 Hz/s (steps 0.1 Hz/s);
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Times	
Pickup times df/dt	Approx. 200 ms
Drop-off times df/dt	Approx. 200 ms
Drop-off ratio df/dt	Approx. 0.95 or 0.1 Hz/s
Drop-off ratio V<	Approx. 1.05
Tolerances	
Rate-of-frequency change	Approx. 0.1 Hz/s at V> 0.5 V_N
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Vector jump supervision (voltage)	
Setting ranges	
Stage $\Delta\varphi$	0.5 ° to 15 ° (steps 0.1 °)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking V_1<	10 to 125 V (steps 0.1 V)
Tolerances	
Vector jump	0.3 ° at V> 0.5 V_N
Undervoltage blocking	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

Sensitive earth-fault protection B (ANSI 51GN)	
Setting ranges	
Earth current $I_{EE\text{-}B}$>,	0.3 to 1000 mA (steps 0.1 A)
Earth current $I_{EE\text{-}B}$<,	0.3 to 500 mA (steps 0.1 mA)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Measuring method	- Fundamental, - 3rd harmonica - 1^{rst} and 3rd harmonics
Times	
Pick-up times	Approx. 50 ms
Drop-off times	Approx. 50 ms
Drop-off ratio $I_{EE\text{-}B}$>	0.90 or 0.15 mA
Drop-off ratio $I_{EE\text{-}B}$<	1.1 or 0.15 mA
Tolerances	
Earth current	1 % of set value or 0.1 mA
Time delays T	1 % of set value or 10 ms

Interturn protection (ANSI 59N(IT))	
Setting ranges	
Displacement voltage $V_{Interturn}$>	0.3 to 130 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pick-up times $V_{Interturn}$>	Approx. 60 ms
Drop-off times $V_{Interturn}$>	Approx. 60 ms
Drop-off ratio $V_{Interturn}$>	0.5 to 0.95 adjustable
Tolerances	
Displacement voltage	1 % of set value or 0.5 V
Time delays T	1 % of set value or 10 ms

Incoupling of temperature via serial interface (thermo-box) (ANSI 38)	
Number of measuring sensors	6 or 12
Temperature thresholds	40 to 250 °C or 100 to 480 °F (steps 1 °C or 1 °F)
Sensors types	Pt100; Ni 100, Ni 120

External trip coupling	
Number of external trip couplings	4

Threshold supervision	
Setting ranges	
Threshold of measured values MV_1 > to MV_{10}<	-200 % to +200 % (steps 1 %)
Assignable measured values	P, active power Q, reactive power change of active power ΔP Voltage V_{L1}, V_{L2}, V_{L3}, V_E, V_0, V_1, V_2, V_{E3h} Current 3I_0, I_1, I_2, I_{EE1}, I_{EE2} Power angle φ Power factor cos φ Value at TD1
Times	
Pick-up times	Approx. 20 - 40 ms
Drop-off times	Approx. 20 - 40 ms
Drop-off to pick-up ratio	
Threshold MV_x>	0.95
Threshold MV_x<	1.05

Trip circuit supervision (ANSI 74TC)	
Number of supervised trip circuits	1

Technical data

Operational measured values	
Description	Primary; secondary or per unit (%)
Currents	$I_{L1,S1}$; $I_{L2,S1}$; $I_{L3,S1}$; $I_{L1,S2}$; $I_{L2,S2}$; $I_{L3,S2}$; I_{EE1}; I_{EE2}; I_1; I_2; I_{20Hz}
Tolerance	0.2 % of measurement values or ± 10 mA ± 1 digit
Differential protection currents	I_{DiffL1}; I_{DiffL2}; I_{DiffL3}; I_{RestL1}; I_{RestL2}; I_{RestL3};
Tolerances	0.1 % of measured or ± 10 mA ± 1 digit
Phase angles of currents	$\varphi I_{L1,S1}$; $\varphi I_{L2,S1}$; $\varphi I_{L3,S1}$; $\varphi I_{L1,S2}$; $\varphi I_{L2,S2}$; $\varphi I_{L3,S2}$;
Tolerances	< 0.5 °
Voltages	V_{L1}; V_{L2}; V_{L3}; V_E; V_{L12}; V_{L23}; V_{L31}; V_1; V_2; $V_{20\,Hz}$
Tolerance	0.2 % of measured values or ± 0.2 V ± 1 digit
Impedance Tolerance	R, X 1 %
Power Tolerance	S; P; Q 1 % of measured values or ± 0.25 % S_N
Phase angle Tolerance	φ <0.1 °
Power factor Tolerance	cos φ (p.f.) 1 % ± 1 digit
Frequency Tolerance	f 10 mHz (at V> 0.5 V_N; 40 Hz < f < 65 Hz)
Overexcitation Tolerance	V/f; 1 %
Thermal measurement Tolerance	Θ_{L1}; Θ_{L2}, Θ_{L3}, Θ_{I2}, $\Theta_{V/f}$, sensors 5 %
Min./max. memory	
Memory	Measured values with date and time
Reset manual	Via binary input Via key pad Via communication
Values Positive sequence voltage Positive sequence current Active power Reactive power Frequency Displacement voltage (3rd harmonics)	 V_1 I_1 P Q f $V_{E(3rd\ harm.)}$
Energy metering	
Meter of 4 quadrants	W_{P+}; W_{P-}; W_{Q+}; W_{Q-}
Tolerance	1 %
Analog outputs (optional)	
Number	max. 4 (depending on variant)
Possible measured values	I_1, I_2, I_{EE1}, I_{EE2}, V_1, V_0, V_{03h}, |P|, |Q|, |S|, |cos φ| f, V/f, φ, $\Theta_S/\Theta_{S\ Trip}$, $\Theta_{Rotor}/\Theta_{Rotor\ Trip}$, $R_{E,\ REF}$; $R_{E,\ REF\ 1\text{-}3Hz}$; $R_{E\ SEF}$
Range	0 to 22.5 mA
Minimum threshold (limit of validity)	0 to 5 mA (steps 0.1 mA)
Maximum threshold	22 mA (fixed)
Configurable reference value 20 mA	10 to 1000 % (steps 0.1 %)

Fault records	
Number of fault records	Max. 8 fault records
Instantaneous values Storage time Sampling interval Channels	 Max. 5 s Depending on the actual frequency (e. g. 1.25 ms at 50 Hz; 1.04 ms at 60 Hz) v_{L1}, v_{L2}, v_{L3}, v_E; $i_{L1,S1}$; $i_{L2,S1}$; $i_{L3,S1}$; i_{EE1}; $i_{L1,S2}$; $i_{L2,S2}$; $i_{L3,S2}$; i_{EE2}; TD1; TD2; TD3
R.m.s. values Storage period Sampling interval Channels	 Max. 80 s Fixed (20 ms at 50 Hz; 16.67 ms at 60 Hz) V_1, V_E, I_1, I_2, I_{EE1}, I_{EE2}, P, Q, φ, R, X, f-f_n
Additional functions	
Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits (criterion: current threshold)
Switching statistics	Number of breaker operation Phase-summated tripping current

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Order Code
7UM62 multifunction generator, motor and transformer protection relay	*7UM62□□-□□□□□-□□□0*	*□□□*
Housing, binary inputs and outputs		
Housing 1/2 19", 7 BI, 12 BO, 1 live status contact	*1*	
Housing 1/1 19", 15 BI, 20 BO, 1 live status contact	*2*	
Graphic display, 1/2 19", 7BI, 12 BO, 1 live status contact	*3*	
Current transformer I_N		
1 A[1)], I_{EE} (sensitive)	*1*	
5 A[1)], I_{EE} (sensitive)	*5*	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V[3)]	*2*	
60 to 125 V DC[2)], threshold binary input 19 V[3)]	*4*	
110 to 250 V DC[2)], 115 V/230 V AC, threshold binary input 88 V[3)]	*5*	
220 to 250 V DC, 115 V/230 V AC, threshold binary input 176 V	*6*	
Unit version		
For panel surface mounting, 2-tier screw-type terminals top/bottom	*B*	
For panel flush mounting, plug-in terminals (2-/3- pin connector)	*D*	
Flush-mounting housing, screw-type terminal (direct connection, ring-type cable lugs)	*E*	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, IEC characteristics, language: German, (language can be selected)	*A*	
Region World, 50/60 Hz, IEC/ANSI characteristics, language: English (UK), (language can be selected)	*B*	
Region US, 60 Hz, ANSI characteristics, language: English (US), (language can be selected)	*C*	
Port B (System interface)		
No system interface	*0*	
IEC 60870-5-103 protocol, electrical RS232	*1*	
IEC 60870-5-103 protocol, electrical RS485	*2*	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	*3*	
Analog output 2 x 0 to 20 mA	*7*	
PROFIBUS-DP slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP slave, optical 820 nm, double ring, ST connector*	*9*	*L 0 B*
MODBUS, electrical RS485	*9*	*L 0 D*
MODBUS, optical 820 nm, ST connector*	*9*	*L 0 E*
DNP 3.0, electrical RS485	*9*	*L 0 G*
DNP 3.0, optical 820 nm, ST connector*	*9*	*L 0 H*
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connectors	*9*	*L 0 R*
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector[4)]	*9*	*L 0 S*
Only Port C (Service Interface)		
DIGSI 4 / modem, electrical RS232	*1*	
DIGSI 4 / modem, temperature monitoring box, electrical RS485	*2*	
Port C (Service interface) and Port D (Additional Interface)	*9*	*M □ □*
Port C (Service Interface)		
DIGSI 4 / modem, electrical RS232		*1*
DIGSI 4 / modem, temperature monitoring box, electrical RS485		*2*
Port D (Additional Interface)		
Temperature monitoring box, optical 820 nm, ST connector		*A*
Temperature monitoring box, electrical RS485		*F*
Analog outputs 2 x 0 to 20 mA		*K*

Cont'd on next page

1) Rated current can be selected by means of jumpers.

2) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.

3) The binary input thresholds can be selected in stages by means of jumpers.

4) Not available with position 9 = "*B*"

* Not with position 9 = *B*; if 9 = "*B*", please order 7UM61 unit with RS485 port and separate fiber-optic converters.

Selection and ordering data

Description	Order No.
7UM62 multifunction generator, motor and transformer protection	*7UM62□□-□□□□□-□□□0*
Measuring functions	
Without extended measuring functions	*0*
Min./max. values, energy metering	*3*
Functions[1]	
Generator Basic	*A*
Generator Standard	*B*
Generator Full	*C*
Asynchronous Motor	*F*
Transformer	*H*
Functions (additional functions)[1]	
Without	*A*
Sensitive rotor earth-fault protection and 100 % stator earth-fault protection	*B*
Restricted earth-fault protection	*C*
Network decoupling (d*f*/d*t* and vector jump)	*E*
All additional functions	*G*

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as "Getting started" manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	*7XS5400-0AA00*
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	*7XS5402-0AA00*
Professional + IEC 61850 Complete version DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation) + IEC 61850 system configurator	*7XS5403-0AA00*
IEC 61850 System configurator Software for configuration of stations with IEC 61850 communication under DIGSI, running under MS Windows 2000 or XP Professional Edition Optional package for DIGSI 4 Basis or Professional License for 10 PCs. Authorization by serial number. On CD-ROM	*7XS5460-0AA00*
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 95/98/ME/NT/2000/XP Professional. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	*7XS5410-0AA00*

1) For more detailed information on the functions see Table 11/3.

11

Accessories

Description	Order No.	
Connecting cable		
Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	*7XV5100-4*	
Cable between thermo-box and relay		
- length 5 m / 5.5 yd	*7XV5103-7AA05*	
- length 25 m / 27.3 yd	*7XV5103-7AA25*	
- length 50 m / 54.7 yd	*7XV5103-7AA50*	
Coupling device for rotor earth-fault protection	*7XR6100-0CA00*	
		Short code
Series resistor for rotor earth-fault protection (group: 013002)	*3PP1336-0DZ*	*K2Y*
Resistor for underexcitation protection (voltage divider, 20:1) (group: 012009)	*3PP1326-0BZ*	*K2Y*
Resistor for stator earth-fault protection (voltage divider, 5:1) (group 013001)	*3PP1336-1CZ*	*K2Y*
20 Hz generator	*7XT3300-0CA00*	
20 Hz band pass filter	*7XT3400-0CA00*	
Current transformer (400 A /5 A, 5 VA)	*4NC5225-2CE20*	
Controlling unit f. rotor earth-fault protection (0.5 to 4 Hz)	*7XT7100-0EA00*	
Resistor for 1 to 3 Hz rotor earth-fault protection	*7XR6004-0CA00*	
Temperature monitoring box (thermo-box)		
24 to 60 V AC/DC	*7XV5662-2AD10*	
90 to 240 V AC/DC	*7XV5662-5AD10*	

Fig. 11/62 Mounting rail for 19" rack

Fig. 11/63
2-pin connector

Fig. 11/64
3-pin connector

Fig. 11/65
Short-circuit link for current terminals

Fig. 11/66
Short-circuit link for voltage terminals/ indications terminals

Description		Order No.	Size of package	Supplier	Fig.
Connector	2-pin	*C73334-A1-C35-1*	1	Siemens	11/63
	3-pin	*C73334-A1-C36-1*	1	Siemens	11/64
Crimp connector	CI2 0.5 to 1 mm²	*0-827039-1*	4000	AMP 1)	
		0-827396-1	1	AMP 1)	
	CI2 1 to 2.5 mm²	*0-827040-1*	4000	AMP 1)	
		0-827397-1	1	AMP 1)	
	Type III+ 0.75 to 1.5 mm²	*0-163083-7*	4000	AMP 1)	
		0-163084-2	1	AMP 1)	
Crimping tool	For Type III+	*0-539635-1*	1	AMP 1)	
	and matching female	*0-539668-2*		AMP 1)	
	For CI2	*0-734372-1*	1	AMP 1)	
	and matching female	*1-734387-1*		AMP 1)	
Mounting rail		*C73165-A63-D200-1*	1	Siemens	11/62
Short-circuit links	For current terminals	*C73334-A1-C33-1*	1	Siemens	11/65
	For other terminals	*C73334-A1-C34-1*	1	Siemens	11/66
Safety cover for terminals	Large	*C73334-A1-C31-1*	1	Siemens	11/36
	Small	*C73334-A1-C32-1*	1	Siemens	11/36

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram, IEC

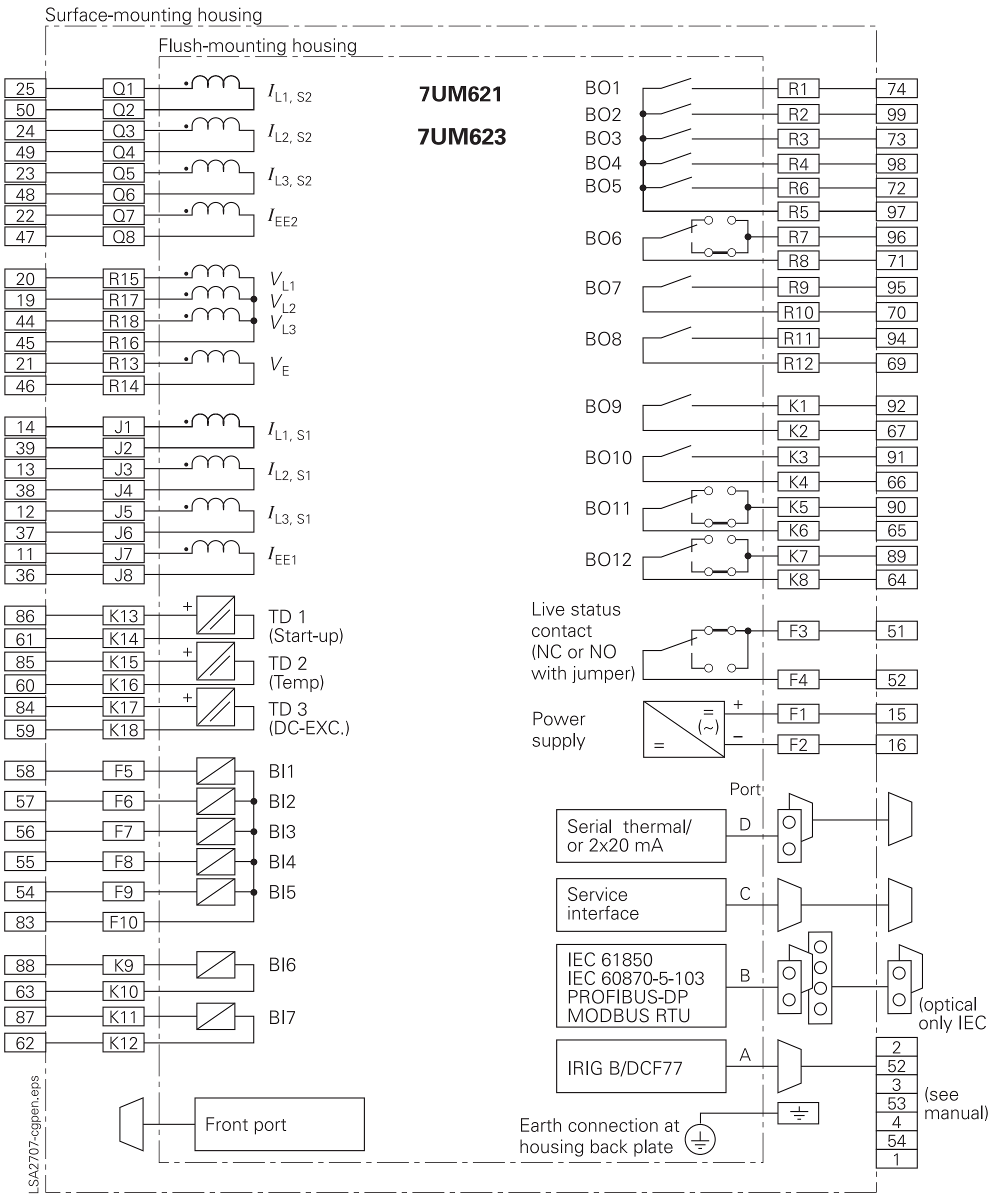


Fig. 11/67
7UM621 and 7UM623 connection diagram (IEC standard)

Connection diagram, IEC

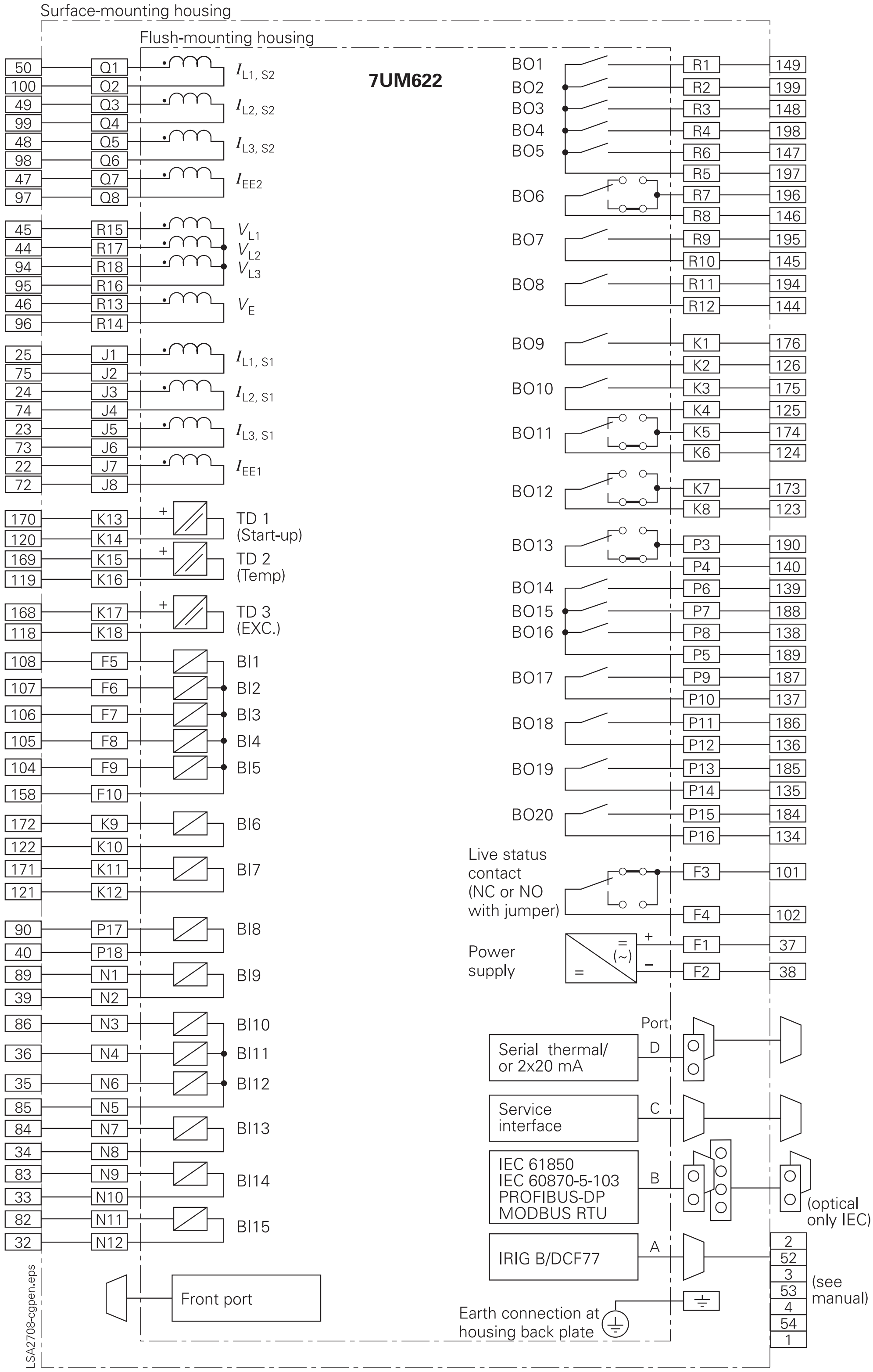


Fig. 11/68

7UM622 connection diagram (IEC standard)

Connection diagram, ANSI

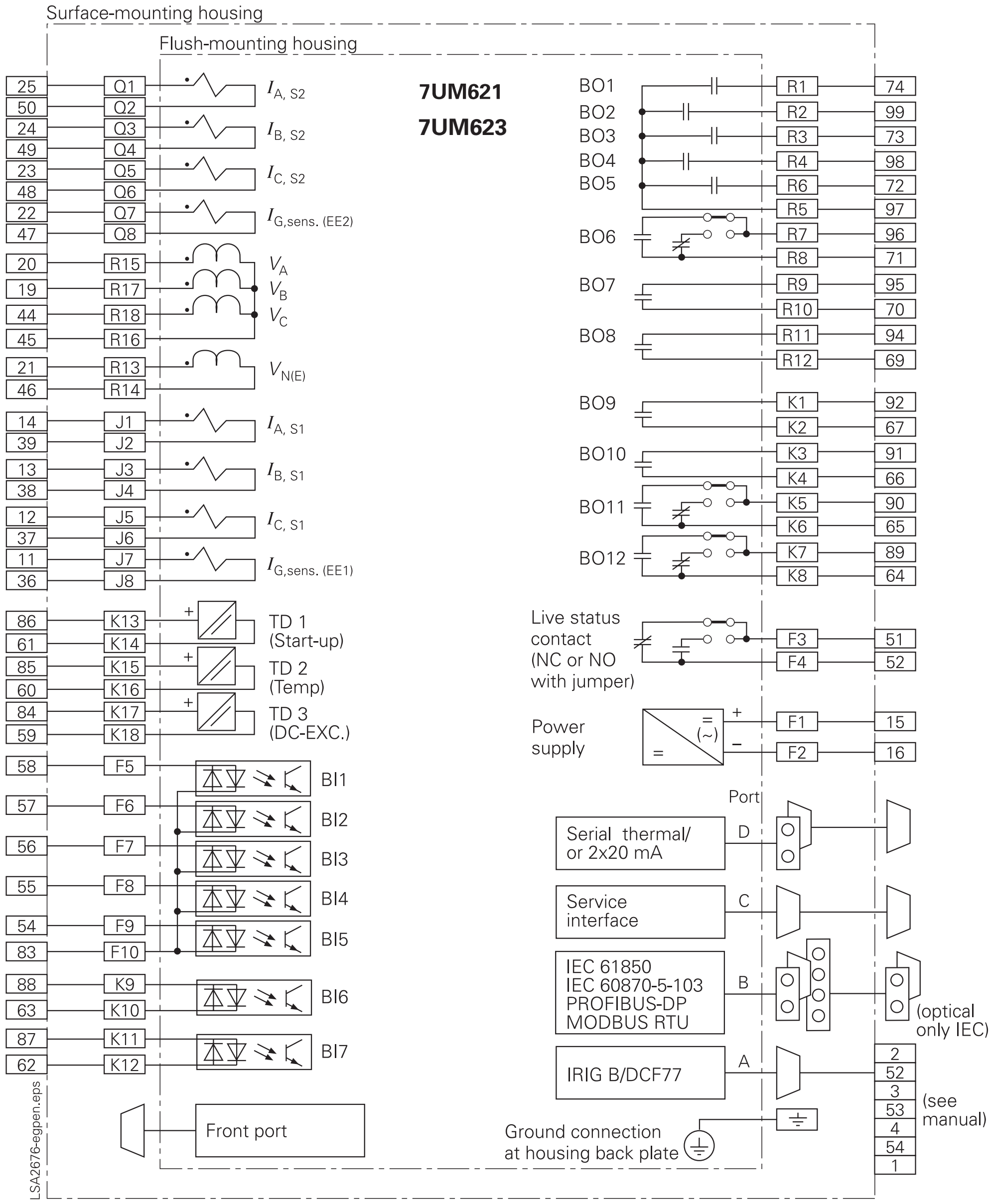


Fig. 11/69

7UM621 and 7UM623 connection diagram (ANSI standard)

Connection diagram, ANSI

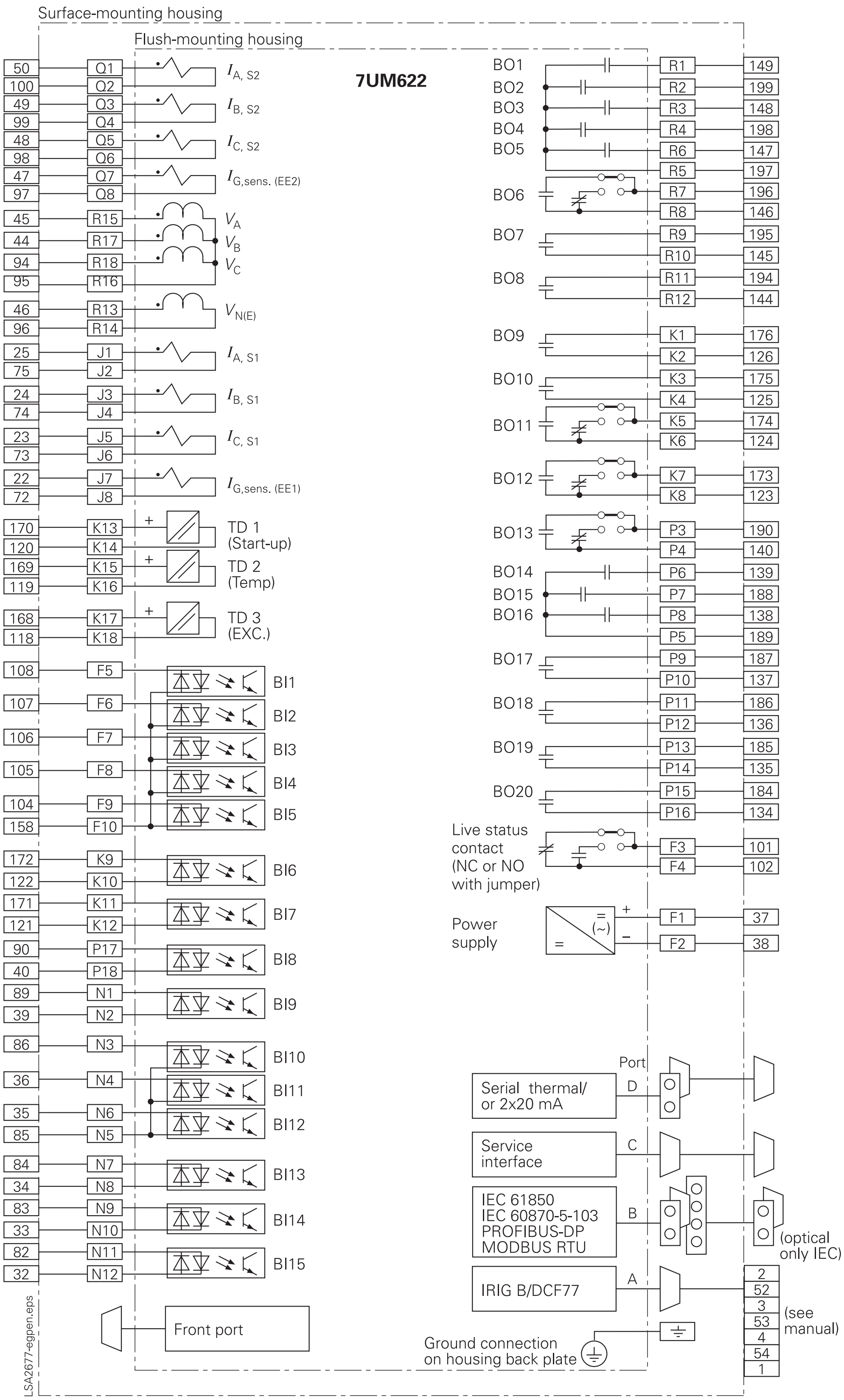


Fig. 11/70

7UM622 connection diagram (ANSI standard)

SIPROTEC 7UW50
Tripping Matrix

LSP2300-afpen.tif

Fig. 11/71 SIPROTEC 7UW50 tripping matrix

Function overview

Functions

- Hardware tripping matrix
- 28 inputs
- 10 outputs
- One LED is assigned to each input and output

Features

- Easy marshalling of trip signals via diode plugs
- Plexiglass cover prevents unauthorized marshalling

Description

The tripping matrix 7UW50 is a component of the Siemens numerical generator protection system. The tripping matrix provides a transparent, easily programmable facility for combining output commands of the trip outputs of individual protection devices with plant items such as the circuit-breakers, de-excitation etc. The matrix was developed for marshalling tripping commands of large power stations.

With its help, the tripping schematic can be temporarily changed, e.g., on the basis of a generator circuit-breaker revision. If the software matrix incorporated in each generator protection unit is used for marshalling the tripping commands, the marshalling in the protection units must be changed for this purpose.

11

Selection and ordering data

Description	Order No.
7UW50 tripping matrix	*7UW5000-□□A00*
Rated auxiliary voltage	
60 V, 110 V, 125 V DC	*4*
220 V, 250 V DC	*5*
Unit design	
For panel surface mounting	*B*
For panel flush mounting or cubicle mounting	*C*

SIPROTEC 7RW600
Numerical Voltage, Frequency and Overexcitation Protection Relay

Fig. 11/72 SIPROTEC 7RW600 voltage, frequency and overexcitation protection relay

Description

The SIPROTEC 7RW600 is a numerical multifunction protection relay for connection to voltage transformers. It can be used in distribution systems, on transformers and for electrical machines. If the SIPROTEC 7RW600 detects any deviation from the permitted voltage, frequency or overexcitation values, it will respond according to the values set. The SIPROTEC 7RW600 can be used for the purposes of system decoupling and for load shedding if ever there is a risk of a system collapse as a result of inadmissibly large frequency drops. Voltage and frequency thresholds can also be monitored.

The SIPROTEC 7RW600 voltage, frequency and overexcitation relay can be used to protect generators and transformers in the event of defective voltage control, of defective frequency control, or of full load rejection, or furthermore islanding generation systems.

This device is intended as a supplement to Siemens substation systems and for use in individual applications. It has two voltage inputs (V; V_x) to which a variety of functions have been assigned. While input V serves all of the implemented functions, input V_x is exclusively dedicated to the voltage protection functions. The scope of functions can be selected from three ordering options.

Function overview

Line protection

- Voltage protection
- Frequency protection

Generator protection

- Voltage protection
- Frequency protection
- Overexcitation protection

Transformer protection

- Voltage protection
- Overexcitation protection

Power system decoupling

- Voltage protection
- Frequency protection

Load shedding

- Frequency protection
- Rate-of-frequency-change protection

Status measured values

Monitoring functions

- Hardware
- Software
- Event logging
- Fault recording
- Continuous self-monitoring

Hardware

- Auxiliary voltages:
  – 24, 48 V DC
  – 60, 110, 125 V DC
  – 220, 250 V DC, 115 V AC
- Local operation
- LCD for setting and analysis
- Housing for
  – Flush-mounting 1/6 19-inch 7XP20;
  – Surface-mounting 1/6 19-inch 7XP20

Communication ports

- Personal computer
- Via RS485 – RS232 converter
- Via modem
- SCADA
  – IEC 60870-5-103 protocol
- Bus-capable

Application

The SIPROTEC 7RW600 is a numerical multifunction protection relay for connection to voltage transformers. It can be used in distribution systems, on transformers and for electrical machines.
If the SIPROTEC 7RW600 detects any deviation from the permitted voltage, frequency or overexcitation values, it will respond according to the values set. The SIPROTEC 7RW600 can be used for the purposes of system decoupling and for load shedding if ever there is a risk of a system collapse as a result of inadmissibly large frequency drops. Voltage and frequency thresholds can also be monitored.

The SIPROTEC 7RW600 voltage, frequency and overexcitation relay can be used to protect generators and transformers in the event of defective voltage control, of defective frequency control, or of full load rejection, or furthermore islanding generation systems.

Applications

ANSI	IEC	Protection functions
27	$V<, t; t = f(V<)$	Undervoltage protection
59 59N	$V>>, t; V>, t$	Overvoltage protection
81 81R	$f>; f<; \left\| \frac{df}{dt} \right\| >; + \frac{df}{dt}$	Frequency protection, rate-of-frequency-change protection
24	$\frac{V}{f} >, t; \frac{V}{f} = f(t)$	Overexcitation protection

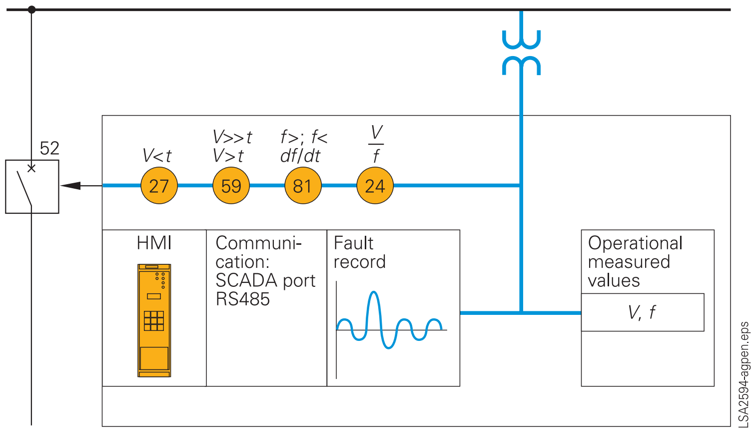


Fig. 11/73 Function diagram

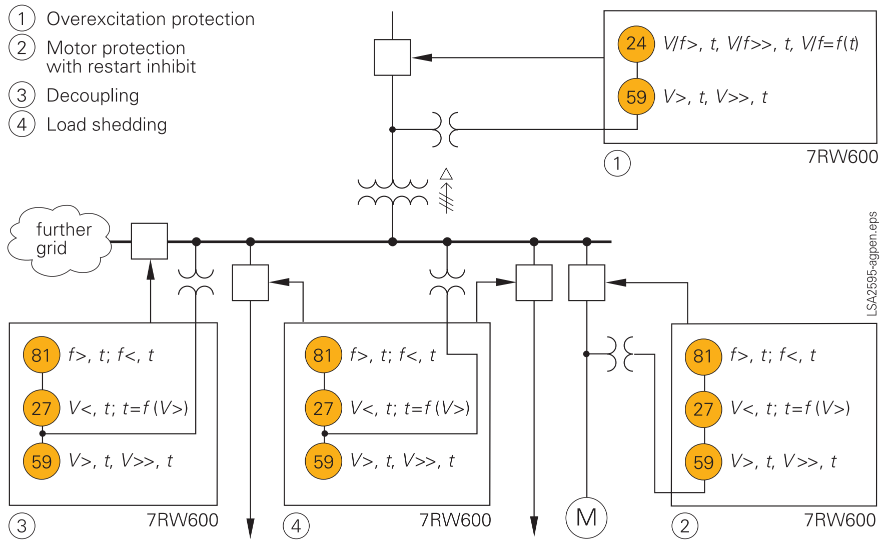


Fig. 11/74

Construction

The SIPROTEC 7RW600 relay contains, in a compact form, all the components needed for:

- Acquisition and evaluation of measured values
- Operation and display
- Output of messages, signals and commands
- Input and evaluation of binary signals
- Data transmission (RS485) and
- Auxiliary voltage supply.

The SIPROTEC 7RW600 receives AC voltages from the primary voltage transformer. The secondary rated voltage range, 100 to 125 V, is adapted internally on the device.

There are two device variants available:

- The first version, for panel flush mounting or cubicle mounting, has its terminals accessible from the rear.
- The second version for panel surface mounting, has its terminals accessible from the front.

Fig. 11/75
Rear view of surface-mounting case

Protection functions

Overvoltage protection

The overvoltage protection has the function of detecting inadmissible overvoltages in power systems and electrical machines and, in such event, it initiates system decoupling or shuts down the generators.

Two voltage measuring inputs (V, V_x) are provided on the unit. These must be connected to two phase-to-phase voltages. The input voltages are processed separately in two two-stage protective functions. From these, two principle connection variants are derived.

Fig. 11/78, Fig. 11/79, and Fig. 11/80, on page 11/80, show the following connection examples:

Fig. 11/78:
Separated connection, used for overvoltage protection and earth-fault detection

Fig. 11/79:
Two-phase connection to a voltage transformer

Fig. 11/80:
Alternative V connection

Undervoltage protection

The main function of the undervoltage protection is protecting electrical machines (e.g. pumped-storage power generators and motors) against the consequences of dangerous voltage drops. It separates the machines from the power system and thus avoids inadmissible operating states and the possible risk of stability loss. This is a necessary criterion in system decoupling.

To ensure that the protection functions in a physically correct manner, when used in conjunction with electrical machines, the positive-sequence system must be evaluated.

The protection function can be blocked, via a binary input, causing a drop in energizing power. The auxiliary contact of the circuit-breaker can be used for this purpose with the circuit-breaker open. Alternatively, undervoltage acquisition can be activated on a conductor-separated basis (V<,V_x<).

Additionally, it is possible to use an inverse-time undervoltage protection function for motor protection. The tripping time depends in the undervoltage drop. A time grading is possible.

Frequency protection

The frequency protection can be used to protect against overfrequency or against underfrequency. It protects electrical machines and plants/substations against adverse effects in the event of deviations in the rated speed (e.g. vibration, heating, etc.), detects and records frequency fluctuations in the power system, and disconnects certain loads according to the thresholds set. It can also be used for the purposes of system decoupling, and thus improves the availability of in-plant power generation.

The frequency protection function is implemented via voltage input V. From the sampled voltage, the frequency is measured by means of various filter functions. The system thus remains unaffected by harmonics, ripple control frequencies and other disturbances.

The frequency protection function operates over a wide frequency range (25-70 Hz).

It is implemented (optionally for overfrequency or for underfrequency) on a four-stage basis; each stage can be individually delayed. The frequency stages can be blocked either via the binary input or by an undervoltage stage.

Rate-of-frequency-change protection

The rate-of-frequency-change protection calculates, from the measured frequency, the gradient of frequency change df/dt. It is thus possible to detect and record any major active power overloading in the power system, to disconnect certain consumers accordingly, and to restore the system to stability. Unlike frequency protection, rate-of-frequency-change protection already reacts before the frequency threshold is undershot. To ensure effective protection settings, power system studies are recommended. The rate-of-frequency-change protection function can also be used for the purposes of system decoupling.

The rate-of-frequency-change protection function is implemented on a four-stage basis; each stage can be individually delayed. It detects and records any negative or positive frequency gradient. The measured result is generally released as soon as the rated frequency is undershot or overshot.

Rate-of-frequency-change protection can also be enabled by an underfrequency or overfrequency stage.

Protection functions

Overexcitation protection

The overexcitation protection detects and records any inadmissibly high induction

$$(B \sim \frac{V}{f})$$

in electrical equipment, e.g. generators or transformers, that may occur as a result of a voltage increase and/or frequency drop. Increased induction of this nature may lead to saturation of the iron core, excessive eddy current losses, and thus to inadmissible heating.

It is recommended to use the overexcitation protection function in power systems subject to large frequency fluctuations (e.g. systems in island configuration or with weak infeed) and for electrical block units that are separated from the system.

The overexcitation protection function calculates, from the maximum voltage (V, V_x) and the frequency, the ratio V/f. This function incorporates an independent warning and tripping stage and a curve which is dependent on and adaptable to the object to be protected and which takes due account of the object's thermal behavior. Incorrect adaptation of the voltage transformer is also corrected. The overexcitation protection function is effective over a broad frequency range (25 to 70 Hz) and voltage range (10 to 170 V).

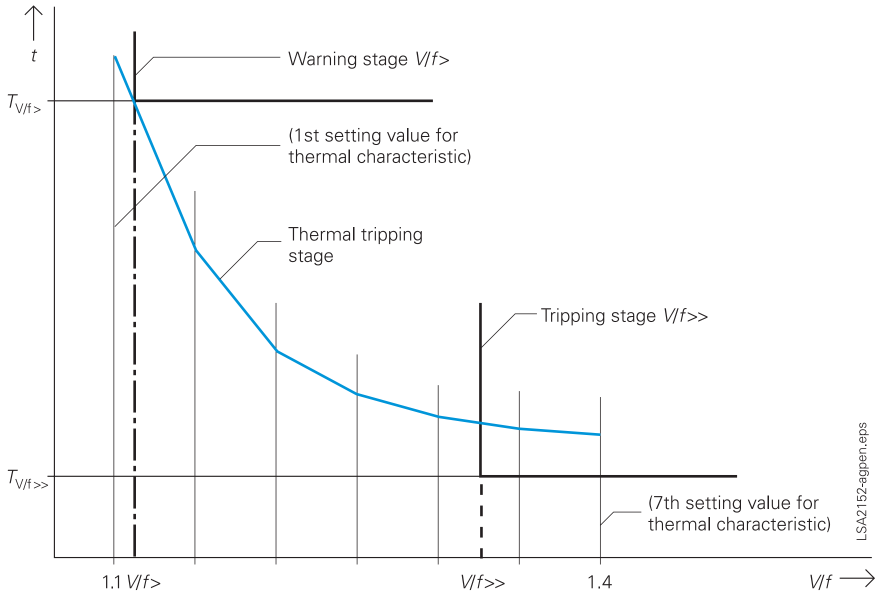


Fig. 11/76 Tripping range of overexcitation protection

Features

Serial data transmission

The SIPROTEC 7RW600 relay is fitted with an RS485 port, via which a PC can be connected, thus providing, in conjunction with the DIGSI operating and analysis program, a convenient tool for configuring and parameter setting. The DIGSI program (which runs under MS-Windows) also performs fault recording and fault evaluation. The SIPROTEC 7RW600 relay can also be linked, via the appropriate converters, either directly or over an optoelectronic connection (optical fiber) to the interface of the PC or substation control system (IEC 60870-5-103 protocol).

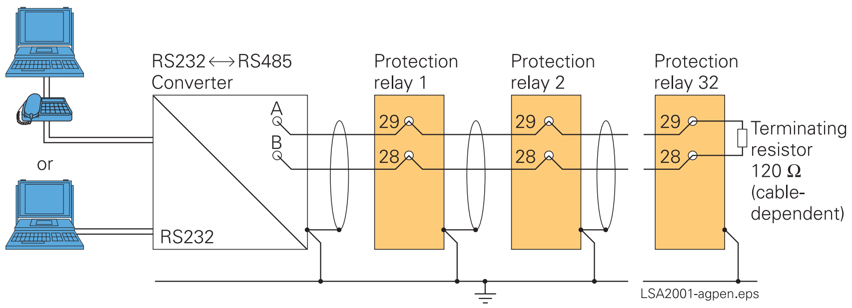


Fig. 11/77 Wiring communication
For convenient wiring of the RS485 bus,
use bus cable system 7XV5103 (see part 14 of this catalog)

Connection diagrams

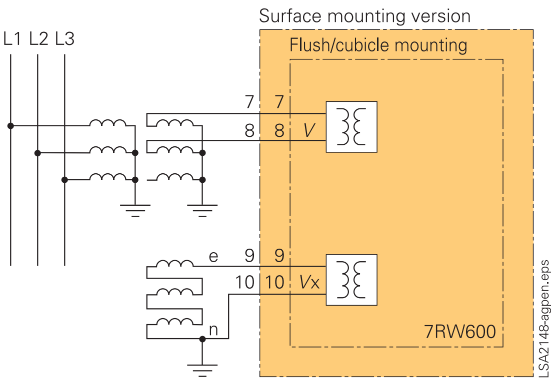


Fig. 11/78
Connection of a phase-to-phase voltage *V* and a displacement voltage V_x

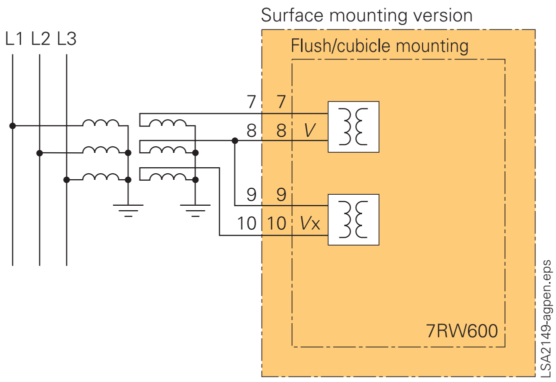


Fig. 11/79
Connection of two phase-to-phase voltages *V* to one voltage transformer set

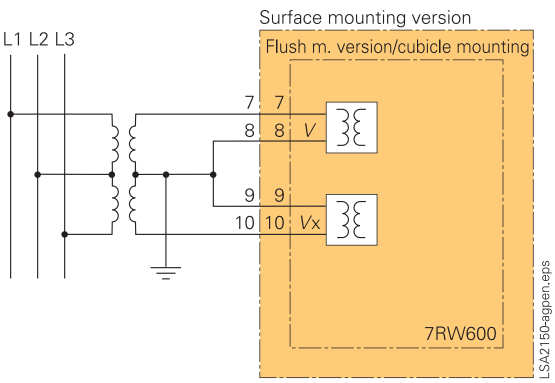


Fig. 11/80
Connection to voltage transformers in *V*-configuration

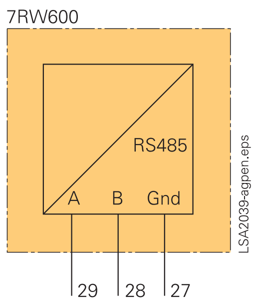


Fig. 11/81
Communication port

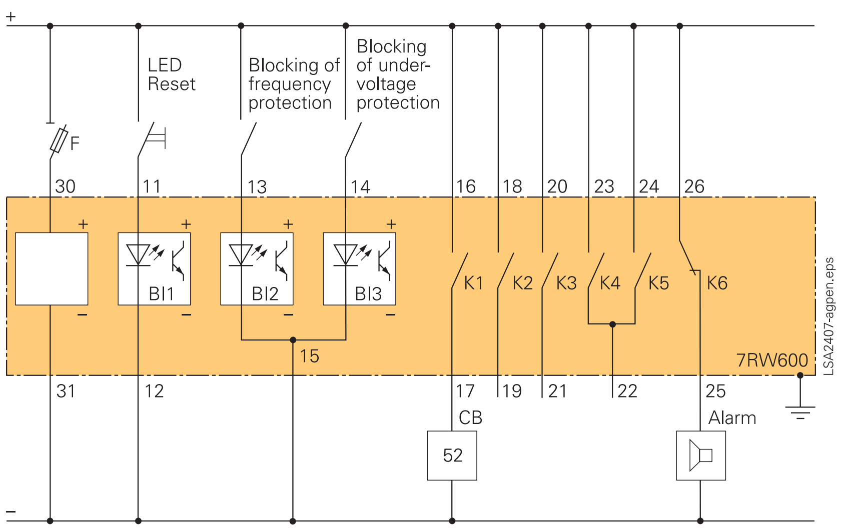


Fig. 11/82
Typical auxiliary voltage wiring

Technical data

Hardware	
Measuring circuits (v.t. circuits)	
Rated voltage V_N	100 to 125 V
Rated frequency f_N	50 or 60 Hz
Dynamic range	170 V
Power consumption	≤ 0.2 VA
Thermal overload capacity, continuous for ≤ 10 s	 200 V 230 V
Power supply via integrated DC/DC converter	
Rated auxiliary voltage V_{aux}	24/48 V DC 60/110/125 V DC 220/250 V DC, 115 V AC
Maximum ripple at rated voltage	≤ 12 %
Power consumption Quiescent Energized	 Approx. 2 W Approx. 4 W
Maximum bridging time following failure of auxiliary voltage	≥ 20 ms at V_{AUX} (24 V DC) ≥ 50 ms at V_{AUX} (110 V DC)
Binary inputs	
Number	3
Voltage range	24 to 250 V DC
Current consumption, independent of operating voltage	Approx. 2.5 mA
2 switching thresholds (adjustable)	17 V, 75 V
Command contacts	
Number of relays, total Number of relays with 2-channel energization	6 2
Contacts per relay (K1 to K5) Contact for relay (K6)	1 NO contact 1 NC contact or 1 NO contact (set via jumper)
Switching capacity Make Break	 1000 W/VA 30 W/VA
Switching voltage	250 V (AC/DC)
Permissible current, continuous 0.5 s	 5 A 30 A
LEDs	
Ready-to-operate (green)	1
Marshallable displays (red)	4
Fault indication (red)	1

Serial port (isolated)	
Type	RS485
Test voltage	2 kV AC for 1 min
Connections	Data cable at housing, two data wires, one frame reference for connection of a PC or similar
Transmission speed	At least 1200 baud, max. 19200 baud
Unit design	
Case 7XP20	For dimensions, see dimension drawings, part 16
Weight Flush mounting/cubicle mounting Surface mounting	 Approx. 4 kg Approx. 4.5 kg
Degree of protection to IEC 60529/EN 60529	IP 51

Electrical test	
Specifications	
Standards	IEC 60255-5, ANSI / IEEE C37.90.0
Insulation tests	
Voltage test (routine test) All circuits except auxiliary voltage and RS485 Auxiliary voltage and RS485 only	 2.0 kV (rms), 50 Hz 2.8 kV DC
Voltage test (type test) Over open command contacts	 1.5 kV (rms), 50 Hz
Impulse withstand capability (SWC) test (type test) All circuits, class III	5 kV (peak); 1.2 / 50 µs; 0.5 J 3 positive and 3 negative impulses at intervals of 5 s
Test crosswise: Measurement circuits, pilot-wire connections, power supply, binary inputs, class III, (no tests crosswise over open contacts, RS485 interface terminals)	
EMC tests, immunity; *type tests*	
Standards	IEC 60255-22 (product standard) EN 50082-2 (generic standard) DIN VDE 0435, Part 303
High-frequency test IEC 60255-22-1, class III and DIN VDE 0435 Part 303, class III	2.5 kV (peak), 1 MHz, τ = 15 µs, 400 shots/s duration 2 s
Electrostatic discharge IEC 60255-22-2, class III and IEC 61000-4-2, class III	4 kV/6 kV contact discharge, 8 kV air discharge, both polarities, 150 pF, R_i = 330 Ω
Irradiation with RF field Non-modulated, IEC 60255-22-3 (report), class III Amplitude-modulated, IEC 61000-4-3, class III Pulse-modulated, IEC 6100-4-3, class III	 10 V/m, 27 to 500 MHz 10 V/m, 80 to 1000 MHz, 80 % AM, 1 kHz 10 V/m, 900 MHz, repetition frequency 200 Hz, duty cycle 50 %

Technical data

EMC tests, immunity; type tests	
Fast transients IEC 60255-22-4 and IEC 61000-4-4, class III	2 kV, 5/50 ns, 5 kHz, burst length 15 ms, repetition rate 300 ms, both polarities, $R_i = 50\ \Omega$, duration 1 min
Conducted disturbances induced by radio-frequency fields, amplitude-modulated, IEC 61000-4-6, class III	10 V, 150 kHz to 80 MHz, 80 % AM, 1 kHz
Power frequency magnetic field IEC 61000-4-8, class IV	30 A/m continuous, 50 Hz 300 A/m for 3 s, 50 Hz 0.5 mT; 50 Hz
Oscillatory surge withstand capability ANSI/IEEE C37.90.1 (common mode)	2.5 kV to 3 kV (peak), 1 MHz to 1.5 MHz, decaying oscillation, 50 shots per s, duration 2 s, R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1 (common mode)	4 to 5 kV, 10/150 ns, 50 shots per s, both polarities, duration 2 s, $R_i = 80\ \Omega$
Radiated electromagnetic interference ANSI/IEEE C37.90.2	10 to 20 V/m, 25 to 1000 MHz, amplitude- and pulse-modulated
High-frequency test Document 17C (SEC) 102	2.5 kV (peak, alternating polarity), 100, 1, 10 and 50 MHz, decaying oscillation, $R_i = 50\ \Omega$
EMC tests, emission; type tests	
Standard	EN 50081-* (generic standard)
Conducted interference voltage, aux. voltage only CISPR 11, EN 55022, DIN VDE 0878 Part 22, limit value, class B	150 kHz to 30 MHz
Interference field strength CISPR 11, EN 55011, DIN VDE 0875 Part 11, limit value, class A	30 to 1000 MHz

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.035 mm amplitude 60 to 150 Hz: 0.5 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 5 *g*, duration 11 ms 3 shocks in each direction of 3 orthogonal axes
Seismic vibration IEC 60255-21-3, class 1 IEC 60068-2-59	Sinusoidal 1 to 8 Hz: ± 4 mm amplitude (horizontal axis) 1 to 8 Hz: ± 2 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Sweep rate 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ± 7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Sweep rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal acceleration 15 *g*, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal acceleration 10 *g*, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

Climatic stress tests	
Temperatures	
Recommended temperature during service	–5 to +55 °C (legibility may be impaired > +55 °C)
Temperature tolerances: During service During storage During transport (storage and transport in standard works packaging)	 –20 to +70 °C –25 to +55 °C –25 to +70 °C
Humidity	
Permissible humidity stress It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity, on 30 days during the year 95 % relative humidity, condensation not permitted!

Functions	
Undervoltage protection	
Setting range $V<$, V_x<V_p<	20 to 120 V (in steps of 1 V)
Delay times	0 to 60 s (in steps of 0.01 s) or ∞ (i.e. non-effective)
Time multiplier for inverse characteristic	0.1 to 5 s
Pickup time	≤ 50 ms
Reset time	≤ 50 ms
Reset ratio	1.05
Tolerances Voltage pickup Delay times	 3 % of setting value or 1 V 1 % of setting value or 10 ms
Overvoltage protection	
Setting range $V>$, $V>>$ $V_x>$, $V_x>>$	 20 to 170 V (in steps of 1 V) 10 to 170 V (in steps of 1 V)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Pickup time	≤ 50 ms
Reset time	≤ 50 ms
Reset ratio	0.95
Tolerances Voltage pickup Delay times	 3 % of setting value or 1 V < 1 % of setting value for $V > V_n$ 1 % of setting value or 10 ms

11

Technical data

Frequency protection	
Number of frequency stages f> or f<	4
Setting range f> or f<	40 to 68 Hz (in steps of 0.01 Hz)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Undervoltage blocking	20 to 100 V or ∞ (in steps of 1 V)
Pickup time f>, f< Reset times f>, f< Reset difference Reset ratio (undervoltage blocking)	Approx. 100 ms Approx. 100 ms Approx. 20 mHz 1.05
Tolerances Frequencies f>, f< Undervoltage blocking Delay times	 5 mHz at $f = f_N$ and $V = V_N$ 10 mHz at $f = f_N$ 3 % of setting value or 1 V 1 % of setting value or 10 ms

Rate-of-frequency-change protection	
Number of rates-of-frequency-changing stages	4
Setting range $\frac{df}{dt}$	0.4 to 10 Hz/s or ∞ (in steps of 0.1 Hz/s)
Delay times	0 to 60 s or ∞ (in steps of 0.01 s)
Undervoltage blocking	20 to 100 V or ∞ (in steps of 1 V)
Pickup time $\frac{df}{dt}$	Approx. 200 ms
Reset ratio pickup $\frac{df}{dt}$	Approx. 0.6
Reset ratio (undervoltage blocking)	1.05
Tolerances Changes of frequencies $\frac{df}{dt}$	
In the 45 to 50 Hz range In the 54 to 60 Hz range	100 mHz/s at $f_N = 50$ Hz and $V = V_N$ 150 mHz/s at $f_N = 60$ Hz and $V = V_N$
Undervoltage blocking V<	3 % of setting value or 1 V
Delay times	1 % of setting value or 10 ms

Overexcitation protection	
Warning stage $\frac{V / V_N}{f / f_N}$	1 to 1.2 (in steps of 0.01)
Tripping stage $\frac{V / V_N}{f / f_N}$	1 to 1.4 (in steps of 0.01)
Delay times, warning and tripping stages Curve values V/f Associated delay times Cooling-down time	0 to 60 s, or ∞ (in steps of 0.01 s) 1.1 / 1.15 / 1.2 / 1.25 / 1.3 / 1.35 / 1.4 0 to 20000 s (in steps of 1 s) 0 to 20000 s (in steps of 1 s)
Voltage transformer adaption factor	0.5 to 2 (in steps 0.01)
Pickup response time (stage curve)	≤ 50 ms
Reset time (stage curve) Reset ratio	≤ 60 ms 0.95
Tolerances Overexcitation V/f Delay times (stage curve) Delay times (dependent curve)	 3 % of setting value 1 % of setting value or 10 ms 5 % with respect to V/f value ± 0.5 s

Fault recording	
Instantaneous value fault record Measured values Pattern Fault record duration Start signal	 V, V_x 1.00 ms (50 Hz) 0.83 ms (60 Hz) Max. 5 s Tripping, energization, binary input, PC
R.m.s. fault record Measured values Pattern Fault record duration Starting signal	 V, V_x, f-f_N 10 ms (50 Hz) 8.3 ms (60 Hz) Max. 50 s Tripping, energization, binary input, PC

Operational measured values	
Measured values	V, V_x, V_1, V/f, f
Measuring range voltage Tolerance	0 to 170 V ≤ 2 V or 5 %
Measuring range overexcitation Tolerance	0 to 2.4 ≤ 5 %
Measuring range frequency Tolerance	25 to 70 Hz ≤ 0.05 Hz or 5 MHz at $f = f_N$

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the "low-voltage Directive".

Selection and ordering data

Description	Order No.
7RW600 numerical voltage, frequency and overexcitation protection relay	*7RW6000-□□A□0-□□A0*
Rated auxiliary voltage	
24, 48 V DC	2
60, 110, 125 V DC	4
220, 250 V DC, 115 V AC	5
Unit design	
For panel surface mounting, terminals on the side	B
For panel flush mounting/cubicle mounting, terminals on the rear	E
Languages	
English	0
German	1
Spanish	2
French	3
Scope of functions	
Voltage and frequency protection	0
Voltage, frequency and rate-of-frequency-change protection	1
Voltage and overexcitation protection	2
Serial system interface	
With RS485 port	D

Accessories

Description	Order No.
DIGSI 4 Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional DIGSI 4 Basis and additionally SIGRA (fault record analysis), CFC Editor (logic editor), Display Editor (editor for default and control displays) and DIGSI 4 Remote (remote operation)	7XS5402-0AA00
SIGRA 4 (generally contained in DIGSI Professional, but can be ordered additionally) Software for graphic visualization, analysis and evaluation of fault records. Can also be used for fault records of devices of other manufacturers (Comtrade format). Running under MS Windows 2000/XP Professional. Incl. templates, electronic manual with license for 10 PCs. Authorization by serial number. On CD-ROM.	7XS5410-0AA00
*Converter RS232 - RS485** With communication cable for the SIPROTEC 7RW600 numerical voltage, frequency and overexcitation relay; length 1 m With plug-in power supply unit 230 V AC	7XV5700-0□□00 1)
With plug-in power supply unit 110 V AC	7XV5700-1□□00 1)
Converter, full-duplex FO cable, RS485, with built-in power supply unit Auxiliary voltage 24 - 250 V DC and 110 / 230 V AC	7XV5650-0BA00
Manual for 7RW600 English	C53000-G1176-C117-4

1) Possible versions see part 14, 7XV57 RS232-RS485 Converter

* RS485 bus system up to 115 kbaud RS485 cable and adaptor 7XV5103-□AA□□see part 14

11

Connection diagrams

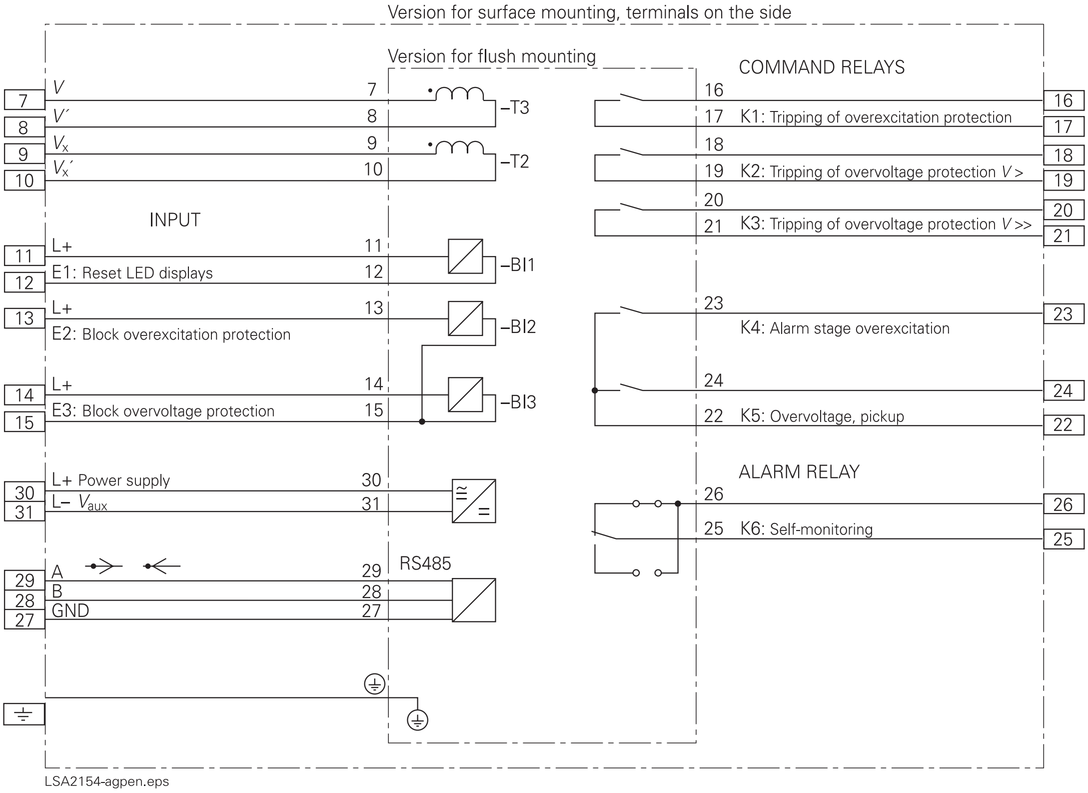


Fig. 11/83
Connection circuit diagram of 7RW600 voltage and frequency protection with pre-setting of marshallable binary inputs and command contacts. (Ordering Code: 7RW600x-xBxxx-; 7RW600x-xExxx-).

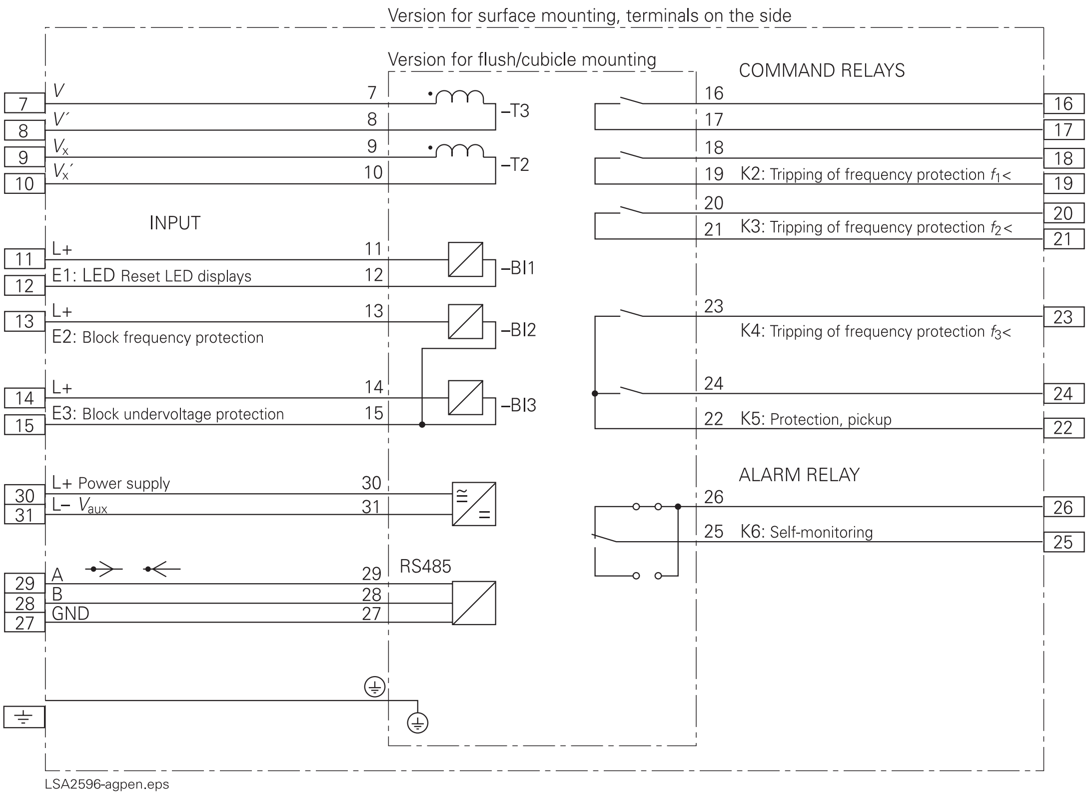


Fig. 11/84
Connection circuit diagram of 7RW600 voltage and overexcitation protection with presetting of marshallable binary inputs and command contacts. (Ordering Code: 7RW600x-xBxxx-; 7RW600x-xExxx-).

11

SIPROTEC 7VE6 Multifunction Paralleling Device

Fig. 11/85

Description

The 7VE61 and 7VE63 paralleling devices of the SIPROTEC 4 family are multifunctional compact units used for paralleling power systems and generators.

Their technical design ensures highly reliable paralleling due to their 1½-channel or 2-channel measurement method and their hardware design. This is supported by numerous monitoring functions.
The units automatically detect the operating conditions. The response to these conditions depends on settings.
In "synchronous network switching" mode, the frequency difference is measured with great accuracy. If the frequency difference is almost zero for a long enough time, the networks are already synchronous and a larger making angle is permissible.

If the conditions are asynchronous, as is the case when synchronizing generators, the generator speed is automatically matched to the system frequency and the generator voltage to the system voltage. The connection is then made at the synchronous point, allowing for circuit-breaker make-time.

The 7VE61 paralleling device is a 1½-channel unit (paralleling function + synchro-check) for use with small to medium-size generators and power systems. It is more reliable than 1-channel paralleling devices. It can also be used for synchro-check, with parallel operation of three synchronization points.

For larger generators and power systems with high reliability requirements, the 2-channel 7VE63 is recommended. Two independent methods decide on the connection conditions. The unit also has the full control functions of the SIPROTEC 4 family.

Voltage and frequency functions ($V>$, $V<$, $f>$, $f<$ df/dt) including voltage vector jump ($\Delta\varphi$) are optionally available for protection or network decoupling applications.

The integrated programmable logic functions (continuous function chart CFC) offer the user a high flexibility so that adjustments can easily be made to the varying requirements on the basis of special system conditions.

The flexible communication interfaces are open to modern communication architectures with control systems.

Function overview

Basic functions

- High reliability with a two-out-of-two design (1 ½ channels in 7VE61 and 2 channels in 7VE63)
- Paralleling of asynchronous voltage sources
- Balancing commands for voltage and speed (frequency)
- Paralleling of synchronous voltage sources
- Synchro-check function for manual synchronization
- Parameter blocks for use on several synchronizing points (7VE61 max. 4 and 7VE63 max. 8)

Additional functions

- Consideration of transformer vector group and tap changer
- Synchronization record (instantaneous or r.m.s. record)
- Commissioning support (CB-time measurement, test synchronization)
- Browser operation
- Full control functionality of SIPROTEC 4
- Analog outputs of operational measured values
- Functions for protection or network decoupling tasks

Protection functions (option)

- Undervoltage protection(27)
- Overvoltage protection (59)
- Frequency protection (81)
- Rate-of-frequency-change protection (81R)
- Jump of voltage vector monitoring

Monitoring functions

- Self-supervision of paralleling function
- Operational measured values
- 8 oscillographic fault records

Communication interfaces

- System interface
  - – IEC 60870-5-103
  - – PROFIBUS-DP
  - – MODBUS RTU and DNP 3.0
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI 4
- Time synchronization via IRIG B/ DCF77

11

Application

The 7VE61 and 7VE63 paralleling devices of the SIPROTEC 4 family are multifunctional compact units used for paralleling power systems and generators.

Their technical design ensures highly reliable paralleling due to their 1½-channel or 2-channel measurement method and their hardware design. This is supported by numerous monitoring functions.

The units automatically detect the operating conditions. The response to these conditions depends on settings.

In “synchronous network switching” mode, the frequency difference is measured with great accuracy. If the frequency difference is almost zero for a long enough time, the networks are already synchronous and a larger making angle is permissible.

If the conditions are asynchronous, as is the case when synchronizing generators, the generator speed is automatically matched to the system frequency and the generator voltage to the system voltage. The connection is then made at the synchronous point, allowing for circuit-breaker make-time.

The 7VE61 paralleling device is a 1½-channel unit (paralleling function + synchro-check) for use with small to medium-size generators and power systems.
It is more reliable than 1-channel paralleling devices. It can also be used for synchro-check, with parallel operation of three synchronization points.

For larger generators and power systems with high reliability requirements, the 2-channel 7VE63 is recommended. Two independent methods decide on the connection conditions. The unit also has the full control functions of the SIPROTEC 4 family.

Voltage and frequency functions (V>, V<, f>, f< df/dt) including voltage vector jump ($\Delta\varphi$) are optionally available for protection or network decoupling applications.

Uniform design

The SIPROTEC 4 units have a uniform design and a degree of functionality which represents a whole new quality in protection and control and automation.
Local operation has been designed according to ergonomic criteria. Large, easy-to-read displays (graphic display for 7VE63) were a major design aim. The DIGSI 4 operating program considerably simplifies planning and engineering and reduces commissioning times.

Highly reliable

The 7VE6 hardware is based on 20 years of Siemens experience with numerical protection equipment. State-of-the-art technology and a high-efficiency, 32-bit microprocessor are employed. Production is subject to exacting quality standards.

Special attention has been paid to electromagnetic compatibility, and the number of electronic modules has been drastically reduced by the use of highly integrated circuits.

The software design incorporates accumulated experience and the latest technical knowledge. Object orientation and high-level language programming, combined with the continuous quality assurance system, ensure maximized software reliability.

Programmable logic

The integrated programmable logic function allows the user to implement his own functions for automation of switchgear (interlocking) via a graphic user interface. The user can also generate user-defined messages.

Adjustments can easily be made to the varying power station requirements.

Measurement method

Powerful and successful algorithms based on years of experience have been incorporated. They ensure both a high level of measurement accuracy and effective noise signal suppression. That makes for reliable paralleling even in networks with harmonics. Complementary measurement methods avoid unwanted operation.

Design

The units are available in two designs: the ½ 19" wide 7VE61 and the ½ 19" wide 7VE63. The 7VE61 features a four-line display. The 7VE63 is equipped with a graphic display for visualization of switching states. It also has a larger number of binary inputs and outputs than the 7VE61.

Communication

Flexible and powerful communication is paramount. That is why the paralleling devices have up to five serial interfaces (for details see chapter 4 "Communication"):

- Front interface for connecting a PC
- Service interface for connecting a PC (e.g. via a modem)
- System interface for connecting to a control system via
  IEC 60870-5-103,
  PROFIBUS-DP,
  MODBUS RTU or
  DNP 3.0
- Interface for an analog output module (2 – 20 mA) and an input
- For time synchronization via DCF77 or IRIG B.

Operational measured values

In order to assist system management and for commissioning purposes, relevant measured values are displayed as primary and secondary values with unit and values relating to the object to be protected.

The measured values can also be transferred via the serial interfaces.

In addition, the programmable logic permits limit value scans and status indications derived therefrom.

Metered values are available in the form of energy metered values for the active and reactive energy supplied and are also provided by an elapsed-hour meter.

11

Application

Indications

The SIPROTEC 4 units provide detailed data for analysis of synchronization (fault events from activated protection functions) and for checking states during operation. All indications are protected against power supply failure.

- **Synchronization indications** (Fault indications)
  The last eight synchronizations (faults) are stored in the unit at all times. A fresh synchronization (fault) will erase the oldest one. The fault indications have a time resolution of 1 ms. They provide detailed information on history. The buffer memory is designed for a total of 600 indications.
- **Operational indications**
  All indications that are not directly associated with the synchronization (fault) (e.g. operating or switching actions) are stored in the status indication buffer. The time resolution is 1 ms, buffer size: 200 indications.

Fault recording at up to 10 or 100 seconds

An instantaneous value or r.m.s. value recorder is provided. The firmware permits storage of 8 fault recordings. Triggering can be effected by the synchronization function (starting or closing command), protection function (pickup or tripping), binary input, the DIGSI 4 operating program or by the control system.

The instantaneous value recording stores the voltage input values (v_a,v_b,v_c,v_d,v_e,v_f), voltage differences (v_a-v_d,v_b-v_e, v_c-v_f), and calculated r.m.s. values ΔV, Δf, $\Delta\alpha$ at 1-ms intervals (or 0.83-ms intervals for 60 Hz). The r.m.s. values are calculated every half cycle. The total duration of the fault recording is 10 seconds. If the time is exceeded, the oldest recording is overwritten.

If you want to record for a longer period for commissioning purposes (for example, to show the effect of balancing commands), r.m.s. value recording is advisable. The relevant calculated values (V_1,V_2, f_1, f_2, ΔV, Δf, $\Delta\alpha$) are recorded at half-cycle intervals. The total duration is 100 seconds.

Time synchronization

A battery-backed clock is a standard component and can be synchronized via a synchronization signal (DCF77; IRIG B via satellite receiver), binary input, system interface or SCADA (e.g. SICAM). A date and time are assigned to every indication.

Freely assignable binary inputs and outputs

Binary inputs, output relays, and LEDs can each be given separate user-specific assignments. Assignment is effected using a software matrix, which greatly simplifies the allocation of individual signals.

To ensure dual-channel redundancy, control of the CLOSE relay (relay R1 and R2) is prioritized and should not be altered. These two relays have a special, highly reliable control and monitoring logic (see Fig. 11/91).

Continuous self-monitoring

The hardware and software are continuously monitored. If abnormal conditions are detected, the unit signals immediately. In this way, a great degree of safety, reliability and availability is achieved.

Reliable battery monitoring

The battery buffers the indications and fault recordings in the event of power supply voltage failure. Its function is checked at regular intervals by the processor. If the capacity of the battery is found to be declining, an alarm indication is generated.

All setting parameters are stored in the Flash-EPROM which are not lost if the power supply or battery fails. The SIPROTEC 4 unit remains fully functional.

Functions

Functional scope of the paralleling function

The units contain numerous individually settable functions for different applications. They cover the following operating modes:

Synchro-check

In this mode, the variables ΔV, Δf, $\Delta\alpha$ are checked. If they reach set values, a release command is issued for as long as all three conditions are met, but at least for a settable time.

Switching synchronous networks

The characteristic of synchronous networks is their identical frequency ($\Delta f \approx 0$). This state is detected, and fulfillment of the ΔV and $\Delta\alpha$ conditions is checked. If the conditions remain met for a set time, the CLOSE command is issued.

Switching asynchronous networks

This state occurs in the power system and generator (open generator circuit-breaker). A check is made for fulfillment of ΔV and Δf conditions and the connection time is calculated, taking account of $\Delta\alpha$, and the circuit-breaker making time. By means of balancing commands (for voltage and frequency), the generator can automatically be put into a synchronous condition.

Switching onto dead busbars

The voltage inputs are checked here. The CLOSE command is issued depending on the set program and the result of measurement. A three-phase connection increases reliability because several voltages must fulfill the conditions (see Fig. 11/86).

The following operating states are possible:
– $V1<$ $V2>$
  (connection to dead busbar (side 1))
– $V1>$ $V2<$
  (connection to dead line (side 2))
– $V1<$ $V2<$
  (forced closing)

11

Functions

Voltage and frequency band query

Synchronization is not activated until the set limits are reached. Then the remaining parameters (see above) are checked.

Vector group adaptation

If synchronization is effected using a transformer, the unit will take account of the phase-angle rotation of the voltage phasor in accordance with the vector group entry for the transformer. On transformers with a tap changer, the tap setting can be communicated to the unit, for example, as BCD code (implemented in the 7VE63). Deviations from the rated transformation ratio result in the appropriate voltage amplitude adaptation.

Voltage and frequency balancing

If the synchronization conditions are not fulfilled, the unit will automatically issue balancing signals. These are the appropriate up or down commands to the voltage or speed controller (frequency controller). The balancing signals are proportional to the voltage or frequency difference, which means that if the voltage or frequency difference is substantial, longer balancing commands will be output. A set pause is allowed to elapse between balancing commands to allow the state change to settle. This method ensures rapid balancing of the generator voltage or frequency to the target conditions.

If identical frequency is detected during generator-network synchronization ("motionless synchronization phasor"), a kick pulse will put the generator out of this state.

For example, if the voltage is to be adjusted using the transformer tap changer, a defined control pulse will be issued.

Several synchronizing points

Depending on the ordered scope, several synchronization points can be operated. The data for synchronization of each circuit-breaker (synchronization function group) are stored individually. In the maximum version, the 7VE63 operates up to 8 synchronization points. Selection is made either via the binary input or the serial interface. With the CFC, it is also possible to control the connection of the measured variables or commands via a master relay.

Commissioning aids

The paralleling device is designed to be commissioned without an external tester/recorder (see Fig. 11/86). For that purpose, it contains a codeword-protected commissioning section. This can be used to measure the make time automatically with the unit (internal command issue until the CB poles are closed). This process is logged by the fault recording function.

The operational measured values also include all measured values required for commissioning. The behavior of the paralleling function or the unit is also documented in detail in the operational annunciation and synchronization annunciation buffer. The connection conditions are documented in the synchronization record. Test synchronization is also permitted. All actions inside the synchronizer are taken but the two CLOSE relays are not operated (R1 and R2). This state can also be initiated via a binary input.

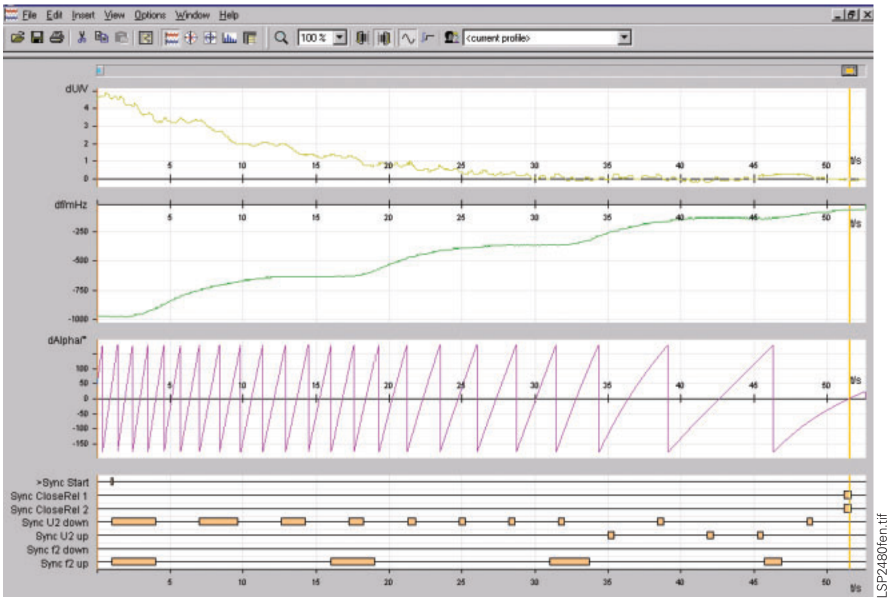


Fig. 11/86
SIGRA 4, synchronization record with balancing commands

11

Functions

Great safety and reliability due to multi-channel redundancy

Generator synchronization especially requires units in which unwanted operation can be ruled out. The paralleling device achieves this multi-channel redundancy with a two-out-of-two decision. That means that two conditions for the CLOSE command must be fulfilled. Fig. 11/87 shows the structure of the two designs.

In the 1½-channel version (7VE61), the paralleling function is the function that gives the CLOSE command. The synchro-check function acts as a release criterion with rougher monitoring limit settings. Other monitoring functions are also active at the same time (see below).

In the two-channel version (7VE63), two independent methods work in parallel. The CLOSE command is given when the two methods simultaneously decide on CLOSE. Fig. 11/88 shows the consistent implementation of dual-channel redundancy.

The measured quantities are fed to two ADCs. The second ADC processes the values rotated through 180° (e.g. $\overline{V1}$). The monitoring methods test all the transformer circuits including internal data acquisition for plausibility and they block measurement if deviations are found. The phase-sequence test detects connection errors. The measuring methods 1 and 2 include the measurement algorithms and logic functions.

In keeping with the two-channel redundancy principle, differing measurement methods are used to prevent unwanted operation due to systematic errors.

In addition, numerous methods are also active, such as closure monitoring (synchronism monitoring of both methods). Unwanted relay operation is avoided by two-channel operation of both CLOSE relays. The two measurement methods operate the transistors crossed over.

Moreover, coil operation is monitored in the background. For this purpose, transistors are activated individually and the response is fed back. Both interruptions and transistor breakdown are detected. When faults are found, the unit is blocked immediately.

The plausibility monitoring of set values (valid limits) and selection of the synchronization function groups (only one can be selected) are also supported. In the event of any deviations, messages are output and the paralleling function is blocked.

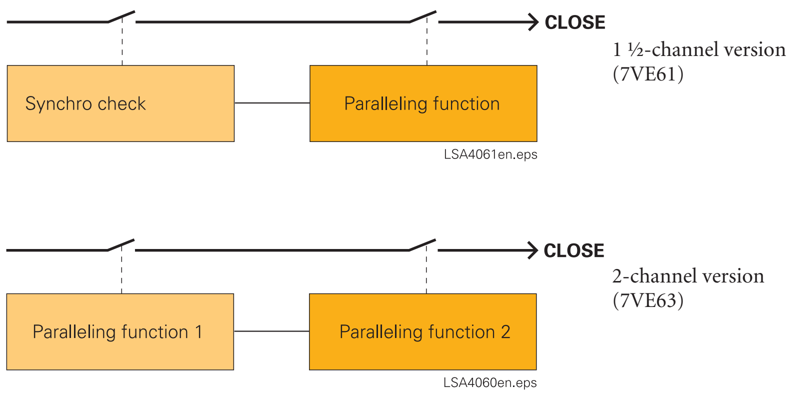


Fig. 11/87
Design of multi-channel redundancy

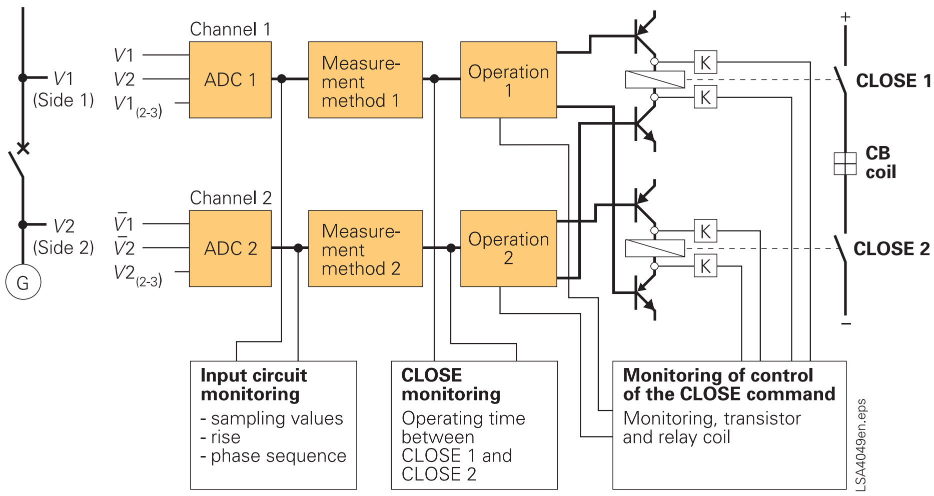


Fig. 11/88
Two-channel redundancy

11

Functions

Internet technology simplifies commissioning

In addition to the universal DIGSI 4 operating program, the synchronizer contains a Web server that can be accessed via a telecommunications link using a browser (e.g. Internet Explorer). The advantage of this solution is that it is both possible to operate the unit with standard software tools and to make use of the Intranet/ Internet infrastructure. Moreover, information can be stored in the unit without any problems. In addition to numeric values, visualizations facilitate work with the unit. In particular, graphical displays provide clear information and a high degree of operating reliability. Fig. 11/90 shows an example of an overview that is familiar from conventional synchronizers. The current status of synchronization conditions is clearly visible. Of course, it is possible to call up further measured value displays and annunciation buffers. By emulation of integrated unit operation, it is also possible to adjust selected settings for commissioning purposes, (see Fig. 11/89).

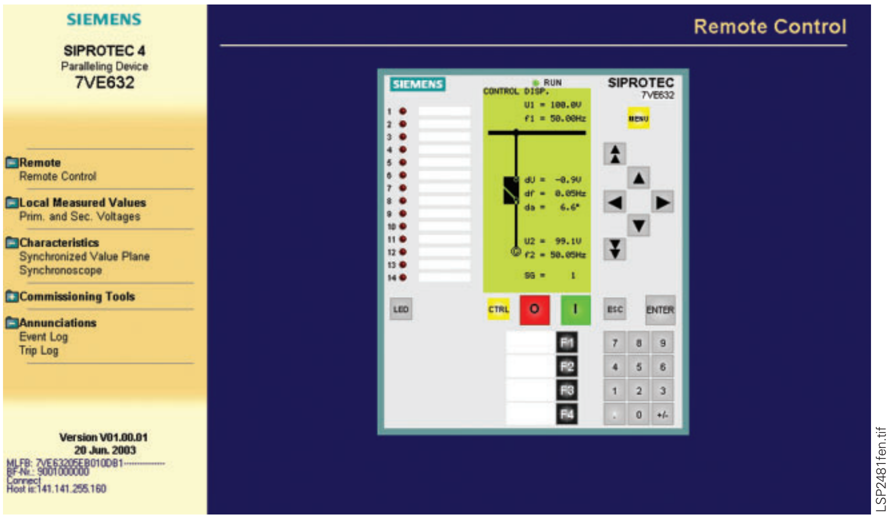


Fig. 5/89 Browser-based operation

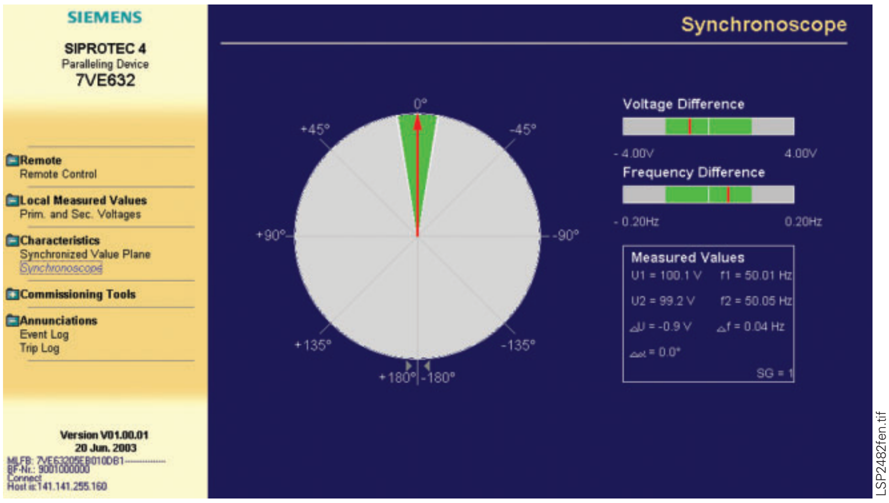


Fig. 11/90
Overview display of the synchronization function

11

Functions

Protection and automation functions

Basic concept

The paralleling function is not performed constantly. Therefore the measured quantities provided at the analog inputs are available for other functions. Voltage and frequency protection or limit value monitoring of these quantities are typical applications. Another possible application is network decoupling. After network disconnection, automatic resynchronization using the CFC is possible on request.
To allow for great flexibility, these functions can be assigned to the analog inputs. This is defined for the specific application.

Undervoltage protection (ANSI 27)

The protection function is implemented on two stages and evaluates the voltage at an input assigned to it. Analysis of a phase-to-phase voltage is beneficial as it avoids starting in the event of earth faults. The protection function can be used for monitoring and decoupling purposes or to prevent voltage-induced instability of generators by disconnection.

Overvoltage protection (ANSI 59)

The protection function is implemented on two stages and evaluates the voltage at an input assigned to it.
The overvoltage protection prevents impermissible stress on equipment due to excessive voltages.

Frequency protection (ANSI 81)

The protection function is implemented on four stages and evaluates the frequency of an input assigned to it. Depending on the frequency threshold setting, the function can provide overfrequency protection (setting $> f_n$) or underfrequency protection (setting $< f_n$. Each stage can be delayed separately. Stage 4 can be configured either as an overfrequency or underfrequency stage.

The application consists of frequency monitoring usually causing network disconnection in the event of any deviations. The function is suitable as a load shedding criterion.

Rate-of-frequency-change protection (ANSI 81R)

This function can also be assigned to an input. The frequency difference is determined on the basis of the calculated frequency over a time interval. It corresponds to the momentary rate-of-frequency change. The function is designed to react to both positive and negative rate-of-frequency changes. Exceeding of the permissible rate-of-frequency change is monitored constantly. Release of the relevant direction depends on whether the actual frequency is above or below the rated frequency. In total, four stages are available, and can be used optionally.

This function is used for fast load shedding or for network decoupling.

Jump of voltage vector monitoring

Smaller generating plants frequently require the vector jump function. With this criterion it is possible to detect a disconnected supply (e.g. due to the dead time during an automatic reclosure) and initiate generator disconnection. This avoids impermissible loads on the generating plant, especially the drive gearing, if reconnection to the network is asynchronous.

The vector jump function monitors the phase angle change in the voltage.

If the incoming line should fail, the abrupt current discontinuity leads to a phase angle jump in the voltage. This is measured by means of a delta process. The command for opening the generator or coupler circuit-breaker is issued if the set threshold is exceeded.

Vector jump monitoring is performed again for the assigned voltage input. This function is blocked during synchronization.

Threshold monitoring

The threshold function is provided for fast monitoring and further processing in the CFC. Optional monitoring of the calculated voltage (for violation of an upper or lower threshold) at the six voltage inputs is possible. A total of three greater-than and three less-than thresholds are available.
The check is made once per cycle, resulting in a minimum operating time of about 30 ms for the voltage. The times can be extended by the internal check time, if necessary (about 1 cycle).

Typical applications

Connection to three-phase voltage transformer

If three-phase voltage transformers are available, connection as shown in Fig. 11/91 is recommended. This is the standard circuit because it provides a high level of reliability for the paralleling function. The phase-sequence test is additionally active, and several voltages are checked on connection to a dead busbar. Interruption in the voltage connection does not lead to unwanted operation. Please note that side 1 (that is, V_1) is always the feed side. That is important for the direction of balancing commands.

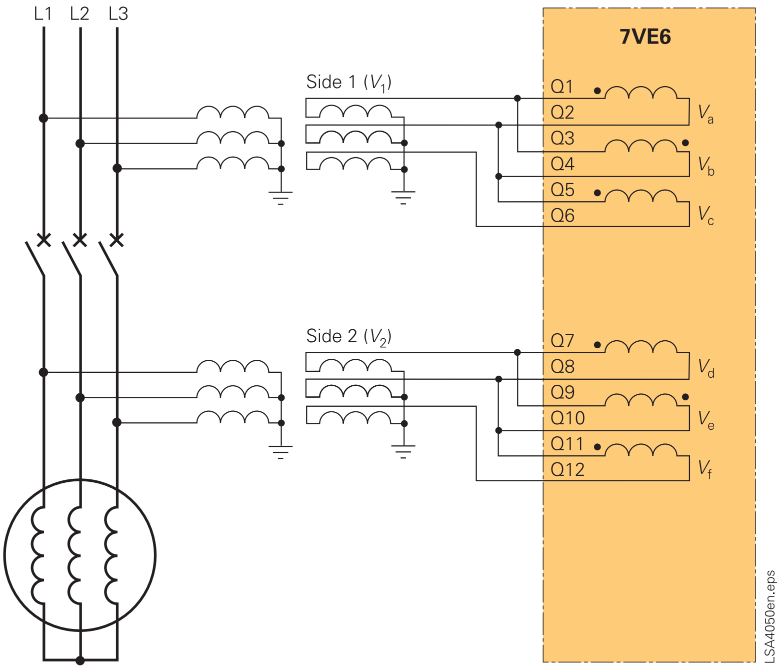


Fig. 11/91

Connection to open delta connection (V-connection) voltage transformer

Fig. 11/92 shows an alternative to Fig. 11/91 for substations in which the voltage transformers have to be V-connected. For the paralleling device, this connection is the electrical equivalent of the connection described above. It is also possible to combine the two: three one-pole isolated voltage transformers on one side and the V-connection on the other. If, additionally, a synchroscope is connected, it must be electrically isolated by means of an interposing transformer.

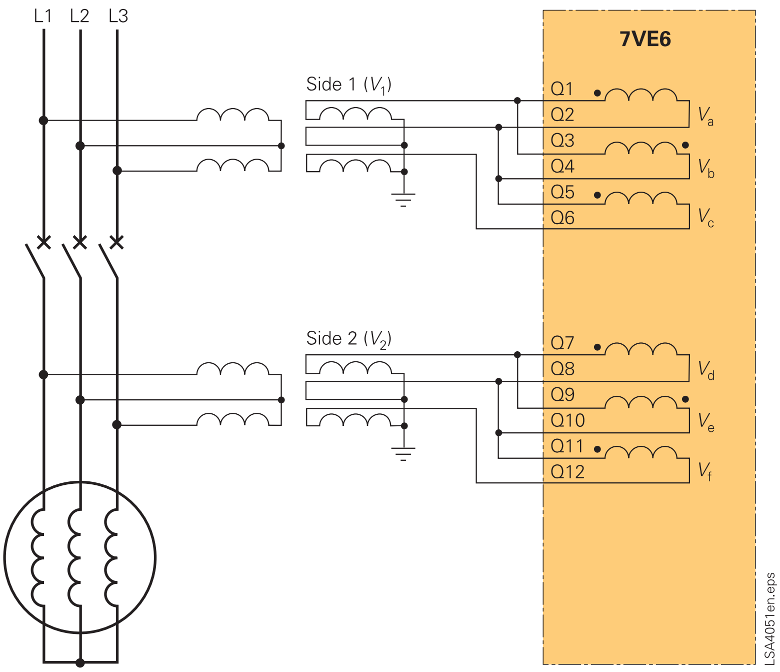


Fig. 11/92

11

Typical applications

Connection to unearthed voltage transformer

To save costs for the voltage transformer, two-phase isolated voltage transformers are used that are connected to the phase-to-phase voltage (see Fig. 11/93). In that case, the phase-rotation supervision is inactive and reliability restrictions when connecting to the dead busbar must be accepted.

Full two-channel redundancy is ensured.

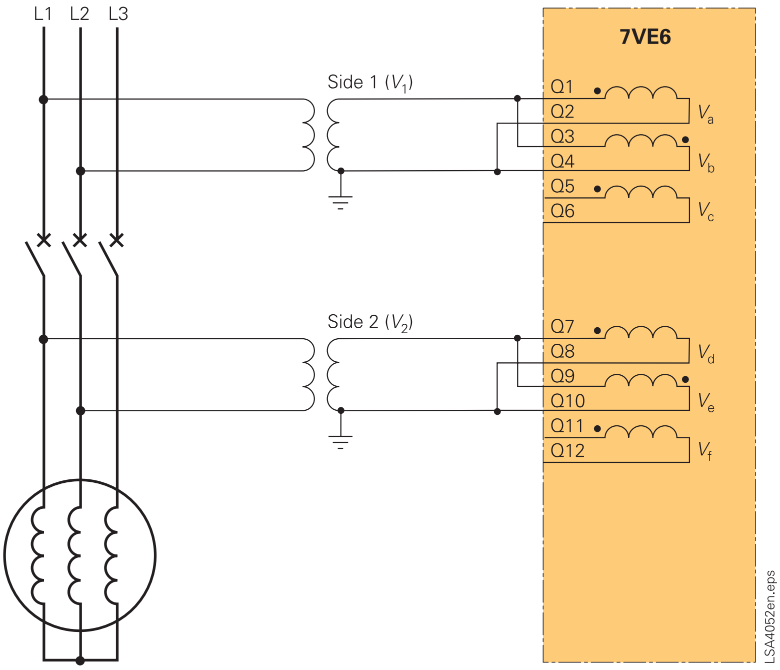


Fig. 11/93

Connection to single-phase isolated voltage transformer

As an alternative to Fig. 11/93, some substations use single-phase isolated voltage transformers (see Fig. 11/94). In this case, only a phase-to-earth voltage is available. This connection should be avoided if possible. Especially in isolated or resonant-(star point) neutral-earthed networks, an earth fault would lead to a voltage value of zero. That does not permit synchronization and the busbar is detected as dead.
If V_1 < and V_2 > connection is permitted, there is a high risk of incorrect synchronization. Furthermore, an earth fault in phase L2 leads to an angle rotation of – for instance – 30° in phase L1. This means that the device switches at a large fault angle.

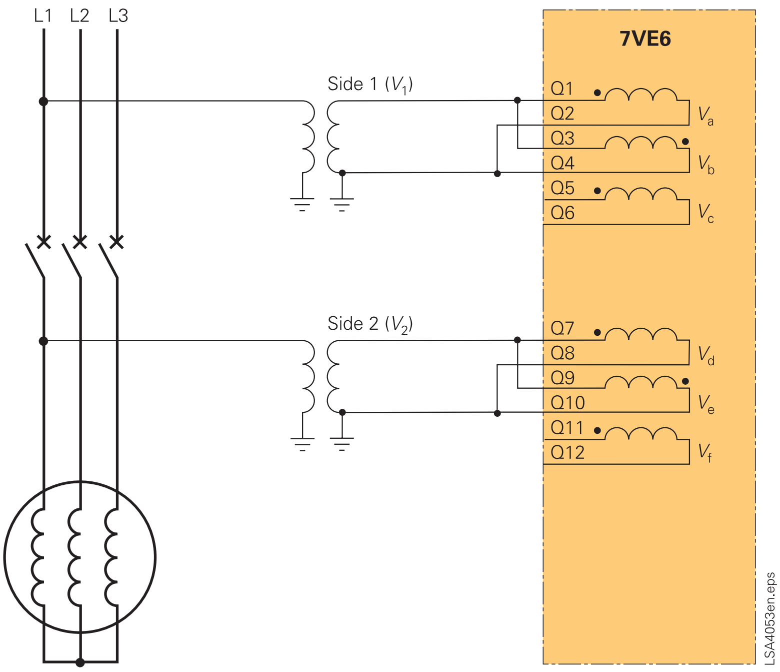


Fig. 11/94

Typical applications

Switching in 16.7 Hz networks for application in traction systems

The unit can also be used for synchronizing railway networks or generators. The connection has to be executed according to Fig. 11/95. No phase sequence test is available here. Two-channel redundancy is ensured.

The voltage inputs permit the application of the 16.7 Hz frequency without any difficulties.

On connection to a dead busbar, a broken wire in the external voltage transformer circuit is not detected. It is recommended to make another interrogation of a second voltage transformer.

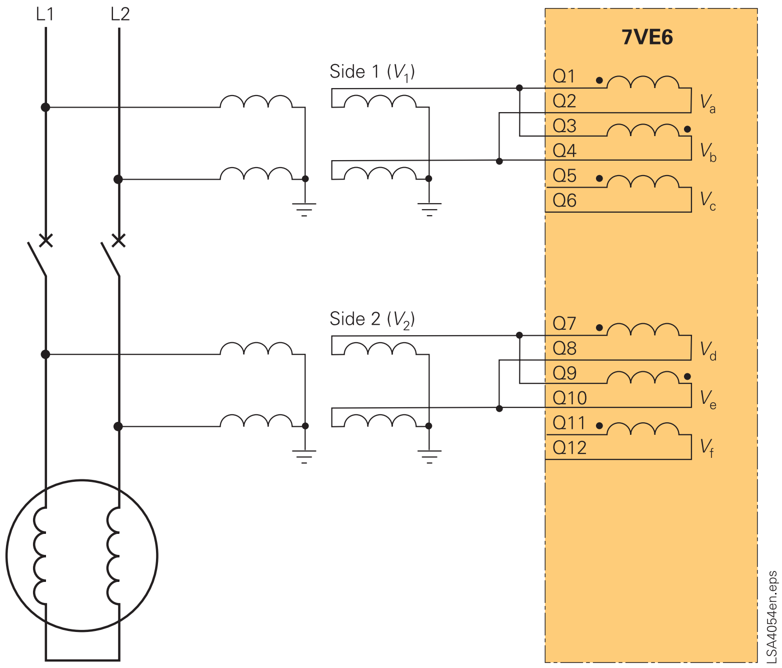


Fig. 11/95

Typical applications

Synchro-check for several synchronizing points

To avoid unwanted operation during manual synchronization or during connection of circuit-breakers in the network, the synchro-check function is used as an enabling criterion. It is fully compatible with all of the connections described above (see Figs. 11/91 to 11/95). With the "synchro-check" ordering option, the paralleling device also allows up to three circuit-breakers to be monitored in parallel. That saves wiring, switching and testing. In particular, that is an application for the 1½ circuit-breaker method. Moreover, on smaller generating plants one unit can be used for up to three generators, which helps reduce costs.

The connection shown in Fig. 11/96 is a single-pole version, which is acceptable for the synchro-check function.

An alternative is the connection for two switching devices (see Fig. 11/97).

The two free voltage inputs can be used for monitoring purposes.

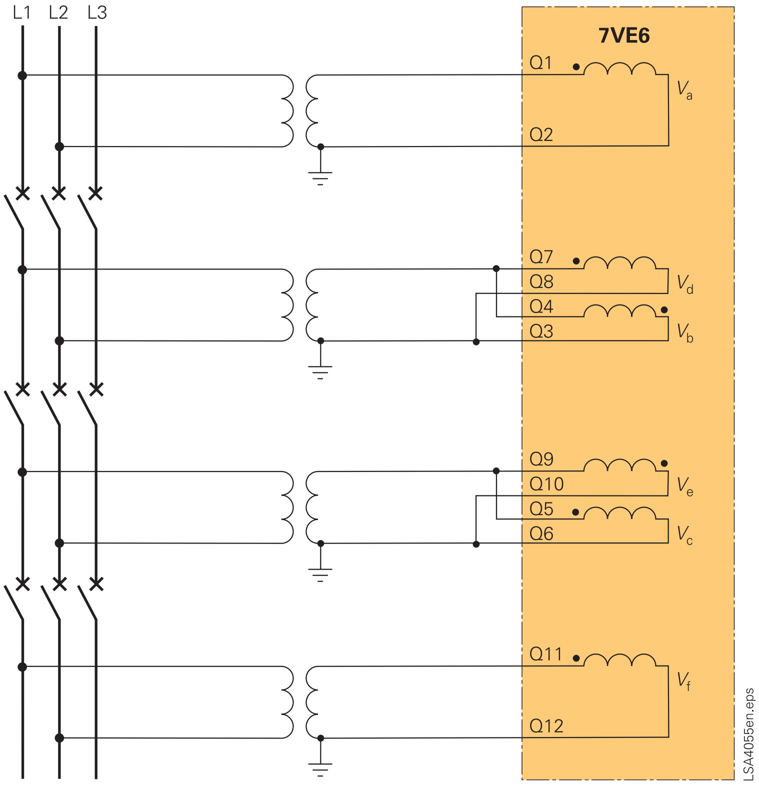


Fig. 11/96

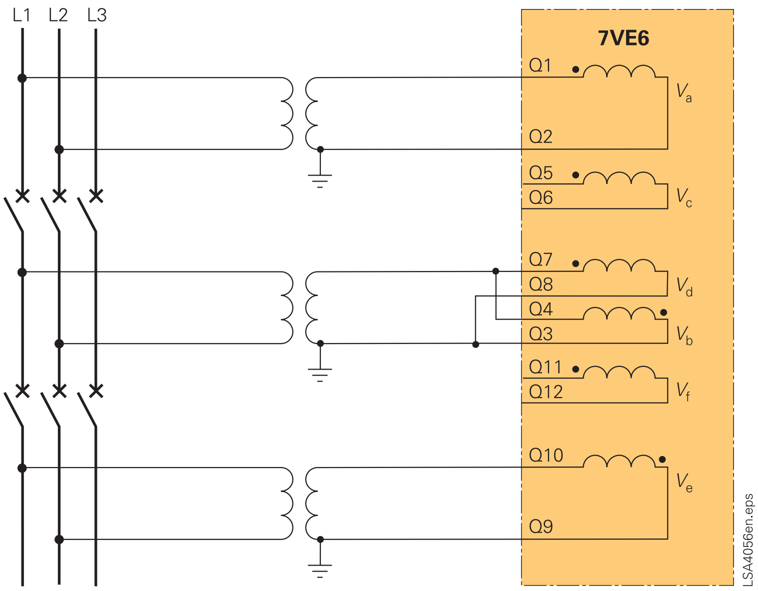


Fig. 11/97

Typical applications

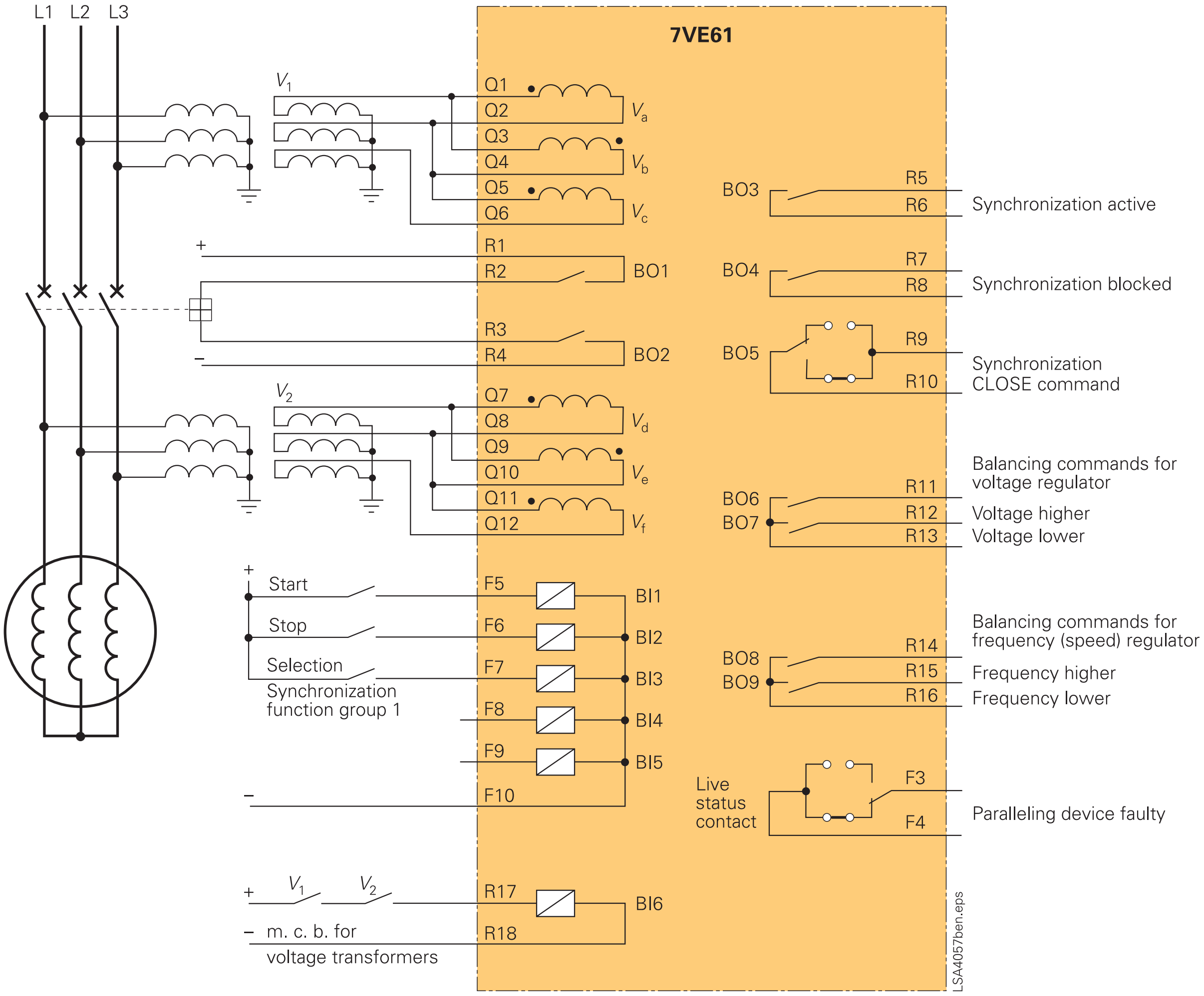


Fig. 11/98

11

Synchronization of a generator

Fig. 11/98 shows an example of the 7VE61 paralleling device connected to a medium-power generator. Where three-phase voltage transformers are available, direct connection is recommended. The synchronization point and start of synchronization is selected via the binary inputs. If cancellation is necessary, the stop input must be used.

If synchronization onto a dead busbar is permitted, the alarm contact of the voltage transformer miniature circuit-breakers (m.c.b.) must be connected to the unit.

Relays R1 and R2 are used for a CLOSE command. The other relays are used for selected indications and for the balancing commands.

The live status contact operated by the unit self-supervision function must also be wired.

Technical data

Hardware	
Analog inputs	
Rated frequency	50, 60 or 16.7 Hz
Rated voltage V_N	100 to 125 V
Power consumption Voltage inputs (at 100 V)	 Approx. 0.3 VA
Capability in voltage paths	230 V continuous
Auxiliary voltage	
Rated auxiliary voltage	24 to 48 V DC 60 to 125 V DC 110 to 250 V DC 220 to 250 V DC 115 and 230 V AC (50/60 Hz)
Permitted tolerance	-20 to +20 %
Superimposed AC voltage (peak-to-peak)	≤ 15 %
Power consumption Quiescent 7VE61 7VE63 Energized 7VE61 7VE63	 Approx. 4 W Approx. 5.5 W Approx. 9.5 W Approx. 12 W
Bridging time during auxiliary voltage failure at V_{aux} = 48 V and V_{aux} ≥ 110 V at V_{aux} = 24 V and V_{aux} = 60 V	 ≥ 50 ms ≥ 20 ms
Binary inputs	
Quantity 7VE61 7VE63	 6 14
3 pickup thresholds Range is settable with jumpers	14 to 19 V DC, 66 to 88 V DC; 117 to 176 V DC
Maximum permissible voltage	300 V DC
Current consumption, energized	Approx. 1.8 mA
Output relays	
Quantity 7VE61 7VE62 7VE61+7VE63	 9 (each with 1 NO; 1 optional as NC, via jumper) 17 (each with 1 NO; 2 optional as NC, via jumper) 1 live status contact (NC, NO via jumper)
Switching capacity Make Break Break (for resistive load) Break (for L/R ≤ 50 ms)	 1000 W / VA 30 VA 40 W 25 W
Switching voltage	250 V
Permissible current	5 A continuous 30 A for 0.5 seconds
LEDs	
Quantity RUN (green) ERROR (red) Assignable LED (red) 7VE61 7VE63	 1 1 7 14

Unit design	
7XP20 housing	For dimensions see dimension drawings
Degree of protection acc. to EN 60529 For surface-mounting housing For flush-mounting housing Front Rear For the terminals	 IP 51 IP 51 IP 50 IP 2x with terminal cover put on
Weight Flush-mounting housing 7VE61 (½ x 19“) 7VE63 (½ x 19“) Surface-mounting housing 7VE61 (½ x 19”) 7VE63 (½ x 19”)	 Approx. 5.2 kg Approx. 7 kg Approx. 9.2 kg Approx. 12 kg

Serial interfaces	
Operating interface for DIGSI 4	
Connection	Non-isolated, RS232, front panel; 9-pin subminiature connector (SUB-D)
Baud rate	4800 to 115,200 baud
Time synchronization IRIG-B / DCF77 signal (Format: IRIG B000)	
Connection	9-pin subminiature connector, (SUB-D), terminal with surface-mounting case
Voltage levels	Selectable 5, 12 or 24 V
Service / modem interface (Port C) for DIGSI 4 / modem / service	
Isolated RS232/RS485 Test voltage Distance for RS232 Distance for RS485	9-pin subminiature connector (SUB-D) 500 V / 50 Hz Max. 15 m Max. 1000 m
System interface (Port B) *IEC 60870-5-103 protocol, PROFIBUS-DP, MODBUS RTU, DNP 3.0)* **and interface (Port D)**	
Isolated RS232/RS485 Baud rate Test voltage Distance for RS232 Distance for RS485	9-pin subminiature connector (SUB-D) 4800 to 115200 Baud 500 V / 50 Hz Max. 15 m Max. 1000 m
RS485: PROFIBUS-DP, MODBUS RTU, DNP 3.0 Test voltage	9-pin subminiature connector (SUB-D) 500 V / 50 Hz
Baud rate PROFIBUS-DP MODBUS RTU, DNP 3.0	 Max. 12 MBaud Max. 19200 Baud
Distance PROFIBUS-DP MODBUS RTU, DNP 3.0	 Max. 1000 m with 93.75 kBaud; Max. 100 m with 12 MBaud 1000 m
Fiber optic: IEC, PROFIBUS-DP, MODBUS RTU, DNP 3.0 PROFIBUS-DP IEC, MODBUS RTU, DNP 3.0 Baud rate PROFIBUS-DP MODBUS RTU, DNP 3.0	ST connector Double ring Point-to-point Max. 1.5 MBaud Max. 19200 Baud
Optical wavelength	λ = 820 nm
Permissible path attenuation	Max. 8 dB, for glass-fiber 62.5/125 µm
Distance	Max. 1.5 km
Analog output module (electrical)	2 ports with 0 to +20 mA

Technical data

Electrical tests	
Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435, part 303 For further standards see below
Insulating tests	
Standards	IEC 60255-5
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs, communication and time synchronization interfaces	2.5 kV (r.m.s.), 50/60 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	3.5 kV DC
Voltage test (100 % test) only isolated communication interfaces and time synchronization interface	500 V (r.m.s. value), 50/60 Hz
Impulse voltage test (type test) All circuits except for communication interfaces and time synchronization interface, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative impulses at intervals of 5 s
EMC tests for noise immunity (type test)	
Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57435 part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; τ = 15 ms 400 pulses per s; duration 2 s
Electrostatic discharge IEC 60255-22-2, class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Irradiation with RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Irradiation with RF field, amplitude-modulated, IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Irradiation with RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation, class III	Impulse: 1.2/50 µs
Auxiliary supply	Common (longitudinal) mode: 2 kV; 12 Ω, 9 µF Differential (transversal) mode: 1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	Common (longitudinal) mode: 2 kV; 42 Ω, 0.5 µF Differential (transversal) mode: 1 kV; 42 Ω, 0.5 µF
Line-conducted HF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz

EMC tests for noise immunity (type test) (cont'd)	
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; Duration 2 s; R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 surges per second; both polarities; duration 2 s ; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
EMC tests for interference emission (type test)	
Standard	EN 50081-1 (generic standard)
Conducted interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz Limit class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz Limit class B

Mechanical stress tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ± 0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Seismic vibration IEC 60255-21-2, class I IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0.5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class II IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class I IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class I IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks in both directions of the 3 axes

Technical data

Climatic stress test

Temperatures

Standards	IEC 60068-2-1, IEC 60068-2-2
Recommended operating limiting temperature	–5 °C to +55 °C / +25 °F to +131 °F
Temporarily permissible operating temperature	-20 to +70 °C (Legibility of display may be impaired above +55 °C / +131 °F)
Limiting temperature during permanent storage (with supplied packing)	–25 °C to +55 °C / –13 °F to +131 °F
Limiting temperature during transport (with supplied packing)	–25 °C to +70 °C / –13 °F to +158 °F

Humidity

Standards	IEC 60068-2-3
Permissible humidity stress	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation is not permitted
It is recommended to arrange the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	

Functions

General

Frequency range	25 to 75 Hz (f_N = 50 Hz) 30 to 90 Hz (f_N = 60 Hz) 8.35 to 25 Hz (f_N = 16.7 Hz)

Paralleling function (ANSI 25)

Setting ranges	
Upper voltage limit V_{max}	20 to 140 V (steps 1 V)
Lower voltage limit V_{min}	20 to 125 V (steps 1 V)
V < for de-energized status	1 to 60 V (steps 1 V)
V > for energized status	20 to 140 V (steps 1 V)
Voltage difference ΔV	0 to 40 V (steps 1 V)
Frequency difference Δf	0 to 2 Hz (steps 0.01 Hz)
Angle difference $\Delta\alpha$	2 to 80° (steps 1°)
Changeover threshold asynchronous – synchronous	0.01 to 0.04 Hz (steps 0.01 Hz)
Angle correction of vector group	0 to 359° (steps 1°)
Matching voltage transformer V_1/V_2	0.5 to 2 (steps 0.01)
Circuit-breaker making time	10 to 1000 ms (steps 1 ms)
Operating time of circuit-breaker	0.01 to 10 s (steps 0.01 s)
Max. operating time after start	0.01 to 1200 s (steps 0.01 s)
Monitoring time of voltage	0 to 60 s (steps 0.1 s)
Release delay	0 to 60 s (steps 0.01 s)
Synchronous switching	0 to 60 s (steps 0.01 s)
Times	
Minimum measuring time	Approx. 80 ms (50/60 Hz) Approx. 240 ms (16.7 Hz)
Drop-off	
Drop-off ratio voltage	Approx. 0.9 (V >) or 1 (V <)
Drop-off difference frequency	20 mHz
Drop-off difference phase angle	1 °
Tolerance	
Voltage measurement	1 % of pickup value or 0.5 V
Voltage difference ΔV	1 % of pickup value or max. 0.5 V (typical < 0.2 V)
Frequency difference Δf	< 10 mHz (synchronous network) < 15 mHz (asynchronous network)
Angle difference $\Delta\alpha$	0.5° with minor slip and approx. rated frequency 3° for Δf < 1 Hz, 5° for Δf > 1 Hz
Delay times	1 % or 10 ms

Readjustment commands for synchronization

Frequency balancing	
Minimum control pulse	10 to 1000 ms (steps 1 ms)
Maximum control pulse	1 to 32 s (steps 0.01 s)
Frequency change of controller	0.05 to 5 Hz/s (steps 0.01 Hz/s)
Setting time of controller	0 to 32 s (steps 0.01 s)
Target value for frequency balancing	-1 to 1 Hz (steps 0.01 Hz)
Kick pulse	Available
Voltage balancing	
Minimum control pulse	10 to 1000 ms (steps 1 ms)
Maximum control pulse	1 to 32 s (steps 0.01 s)
Voltage change of controller	0.1 to 50 V/s (steps 0.1 V/s)
Setting time of controller	0 to 32 s (steps 0.01 s)
Permissible overexcitation $(V/V_N)/(f/f_N)$	1 to 1.4 (steps 0.01)
Tolerances	
Minimum control pulse	1 %
Control times	Approx. 5 % or ± 20 ms

Undervoltage protection (ANSI 27)

Setting range	
Undervoltage pickup V <, V <<	10 to 125 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Times	
Pickup times V <, V <<	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times V <, V <<	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio V <, V <<	1.01 to 1.10 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Overvoltage protection (ANSI 59)

Setting ranges	
Overvoltage pickup V >, V >>	30 to 170 V (steps 0.1 V)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Time	
Pickup times V >, V >>	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times V >, V >>	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio V >, V >>	0.90 to 0.99 (steps 0.01)
Tolerances	
Voltage limit values	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Technical data

Frequency protection (ANSI 81)	
Setting ranges	
Steps; selectable $f>$, $f<$	4
Pickup values $f>$, $f<$	40 to 65 Hz (steps 0.01 Hz)
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Times	
Pickup times $f>$, $f<$	Approx. 100 ms (300 ms at 16.7 Hz)
Drop-off times $f>$, $f<$	Approx. 100 ms (300 ms at 16.7 Hz)
Drop-off difference Δf	Approx. 20 mHz
Drop-off ratio $V<$	Approx. 1.05
Tolerances	
Frequencies	10 mHz at $f = f_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Rate-of-frequency-change protection (ANSI 81R)	
Setting ranges	
Steps, selectable +df/dt >; - df/dt	4
Pickup value df/dt	0.1 to 10 Hz/s (steps 0.1 Hz/s);
Time delays T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Times	
Pickup times df/dt at 16.7 Hz: times x 3	Approx. 200 to 700 ms (depending on measuring duration)
Drop-off times df/dt at 16.7 Hz: times x 3	Approx. 200 to 700 ms (depending on measuring duration)
Drop-off ratio df/dt	0.02 at 0.99 Hz/s (settable)
Drop-off ratio $V <$	Approx. 1.05
Tolerances	
Rate-of-frequency change	Approx. 0.1 Hz/s at $V > 0.5\ V_N$
Measuring duration < 5	Approx. 5 % or 0.15 Hz/s at $V > 0.5\ V_N$
Measuring duration > 5	Approx. 3 % or 0.15 Hz/s at $V > 0.5\ V_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delays T	1 % or 10 ms

Jump of voltage vector monitoring	
Setting ranges	
Stage $\Delta\varphi$	2° to 30° (steps 0.1°)
Time delay T	0 to 60 s (steps 0.01 s) or indefinite
Undervoltage blocking $V<$	10 to 125 V (steps 0.1 V)
Maximum voltage	10 to 170 V (steps 0.1 V)
Times	
Pickup times $\Delta\varphi$	Approx. 75 ms (225 ms at 16.7 Hz)
Drop-off times $\Delta\varphi$	Approx. 75 ms (225 ms at 16.7 Hz)
Tolerances	
Vector jump	0.5° at $V > 0.5\ V_N$
Undervoltage blocking	1 % of set value or 0.5 V
Time delay T	1 % or 10 ms

External trip coupling	
Number of external trip couplings	4

Threshold value supervision	
Number of steps	6 (3 larger and 3 smaller)
Measured quantity	V_a, V_b, V_c, V_d, V_e, V_f
Setting ranges	2 to + 200 % (steps 1 %)
Times	
Pickup times	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off times	Approx. 50 ms (150 ms at 16.7 Hz)
Drop-off ratio	0.95
Voltage tolerance	1 % of set value or 0.5 V

Typical operational measured values	
Description	Secondary
Voltages	V_a; V_b; V_c; V_d; V_e; V_f; V_1, V_2, ΔV
Tolerance	0.2 % of measured value or ± 0.2 V ± 1 digit
Phase angle	$\Delta\alpha$
Tolerance	< 0.5°
Frequency	f_1, f_2, Δf
Tolerance	10 mHz at $f = f_N$ 15 mHz at $f = f_N \pm 10$ %

Fault records	
Number of fault records	Max. 8 fault records
Instantaneous values	
Storage time	Max. 10 s
Sampling interval	Depending on the actual frequency (e. g. 1 ms at 50 Hz; 0.83 ms at 60 Hz)
Channels	V_a, V_b, V_c, V_d, V_e, V_f, V_d-V_a, V_e-V_b, V_f-V_c, ΔV, Δf, $\Delta\alpha$
R.m.s. values	
Storage period	Max. 100 s
Sampling interval	Fixed (10 ms at 50 Hz, 8.33 ms at 60 Hz)
Channels	V_1, V_2, f_1, f_2, ΔV, Δf, $\Delta\alpha$

Additional functions	
Fault event logging	Storage of events of the last 8 faults Puffer length max. 600 indications Time solution 1 ms
Operational indications	Max. 200 indications Time solution 1 ms
Elapsed-hour meter	Up to 6 decimal digits
Switching statistics	Number of break operations Number of make operations

CE conformity

This product is in conformity with the Directives of the European Communities on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and electrical equipment designed for use within certain voltage limits (Council Directive 73/23/EEC).

This unit conforms to the international standard IEC 60255, and the German standard DIN 57435/ Part 303 (corresponding to VDE 0435/Part 303).

The unit has been developed and manufactured for application in an industrial environment according to the EMC standards.

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the Council Directive complying with the generic standards EN 50081-2 and EN 50082-2 for the EMC Directive and standard EN 60255-6 for the “low-voltage Directive”.

Selection and ordering data

Description	Order No.	Order code
7VE61 multifunction paralleling unit *Housing 1/3 19", 6 BI, 9 BO, 1 live status contact*	*7VE6110-□□□□□-0□□□*	*□□□*
Auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC , threshold binary input 19 V	*2*	
60 to 125 V DC, threshold binary input 19 V	*4*	
110 to 250 V DC, 115 to 230 V AC, threshold binary input 88 V DC	*5*	
220 to 250 V DC, 115 to 230 V AC, threshold binary input 176 V DC	*6*	
Unit design		
Surface-mounting housing, 2-tier screw-type terminals at top/bottom	*B*	
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	*E*	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, language German (language selectable)	*A*	
Region World, 50/60 Hz, language English (GB) (language selectable)	*B*	
Region US, 60 Hz, language English (US) (language selectable)	*C*	
Region World, 50/60 Hz, language Spanish (language selectable)	*E*	
Port B (system interface)		
No system interface	*0*	
IEC 60870-5-103-protocol, electrical RS232	*1*	
IEC 60870-5-103-protocol, electrical RS485	*2*	
IEC 60870-5-103-protocol, optical 820 nm, ST connector	*3*	
Analog outputs 2 x 0 to 20 mA or 4 to 20 mA	*7*	
PROFIBUS-DP Slave, electrical RS485	*9*	*L 0 A*
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector 1)	*9*	*L 0 B*
MODBUS RTU, electrical RS485	*9*	*L 0 D*
MODBUS RTU, optical 820 nm, ST connector 1)	*9*	*L 0 E*
DNP 3.0, electrical RS485	*9*	*L 0 G*
DNP 3.0, optical 820 nm, ST connector 1)	*9*	*L 0 H*
Port C (service interface)		
DIGSI 4/modem, electrical RS232	*1*	
DIGSI 4/modem, electrical RS485	*2*	
Port C (service interface) and Port D (additional interface)		
Port C (service interface)		
DIGSI 4/modem, electrical RS232	*9*	*M 1 □*
DIGSI 4/modem, electrical RS485	*9*	*M 2 □*
Port D (additional interface)		
Analog outputs 2 x 0 to 20 mA or 4 to20 mA		*K*
Scope of functions of the unit		
Synchro-check for up to 3 synchronizing points (with dead bus/line monitoring)	*A*	
Paralleling function for 2 synchronizing points without balancing commands, 1½-channel, synchro-check in 2nd channel	*B*	
Paralleling function for 2 synchronizing points with balancing commands, 1½-channel, synchro-check in 2nd channel	*C*	
Paralleling function for 4 synchronizing points with balancing commands, 1½-channel, synchro-check in 2nd channel	*D*	
Additional functions		
Without	*A*	
Protection and network decoupling function (voltage, frequency and rate-of-frequency-change protection, vector jump)	*B*	
Additional applications		
Without	*0*	
Application for traction systems (f_n = 16.7 Hz)	*1*	

1) With position 9 = *B* (surface-mounting housing) the unit must be ordered with RS485 interface and a separate FO converter.

11

Selection and ordering data

Description	Order No.	Order code
7VE63 multifunction paralleling unit *Housing 1/2 19", 14 BI, 17 BO,1 live status contact*	7VE6320-□□□□□-0□□□	□□□
Auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC , threshold binary input 19 V DC	2	
60 to 125 V DC, threshold binary input 19 V DC	4	
110 to 250 V DC, 115 to 230 V AC, threshold binary input 88 V DC	5	
220 to 250 V DC, 115 to 230 V AC, threshold binary input 176 V DC	6	
Unit design		
Surface-mounting housing, 2-tier screw-type terminals at top/bottom	B	
Flush-mounting housing, screw-type terminals (direct connection/ring-type cable lugs)	E	
Region-specific default setting/function and language settings		
Region DE, 50 Hz, language German (language selectable)	A	
Region World, 50/60 Hz, language English (GB) (language selectable)	B	
Region US, 60 Hz, language English (US) (language selectable)	C	
Region World, 50/60 Hz, language Spanish (language selectable)	E	
Port B (system interface)		
No system interface	0	
IEC 60870-5-103-protocol, electrical RS232	1	
IEC 60870-5-103-protocol, electrical RS485	2	
IEC 60870-5-103-protocol, optical 820 nm, ST connector	3	
Analog outputs 2 x 0 to 20 mA or 4 to 20 mA	7	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector [1)]	9	L 0 B
MODBUS RTU, electrical RS485	9	L 0 D
MODBUS RTU, optical 820 nm, ST connector [1)]	9	L 0 E
DNP 3.0, electrical RS485	9	L 0 G
DNP 3.0, optical 820 nm, ST connector [1)]	9	L 0 H
Port C (service interface)		
DIGSI 4/modem, electrical RS232	1	
DIGSI 4/modem, electrical RS485	2	
Port C (service interface) and Port D (additional interface)		
Port C (service interface)		
DIGSI 4/modem, electrical RS232	9	M 1 □
DIGSI 4/modem, electrical RS485	9	M 2 □
Port D (additional interface)		
Analog outputs 2 x 0 to 20 mA or 4 to 20 mA		K
Scope of functions of the unit		
Synchro-check for up to 3 synchronizing points (with dead bus/line monitoring)	A	
Paralleling function for 2 synchronizing points without balancing commands, 2-channel, independent measuring procedures	B	
Paralleling function for 2 synchronizing points with balancing commands, 2-channel , independent measuring procedures	C	
Paralleling function for 8 synchronizing points with balancing commands, 2-channel, independent measuring procedures	D	
Additional functions		
Without	A	
Protection and network decoupling function (voltage, frequency and rate-of-frequency-change protection, vector jump)	B	
Additional applications		
Without	0	
Application for traction systems (f_n = 16.7 Hz)	1	

1) With position 9 = B (surface-mounting housing) the unit must be ordered with RS485 interface and a separate FO converter.

Accessories

Description	Order No.
DIGSI 4	
Software for configuration and operation of Siemens protection units running under MS Windows 2000/XP Professional Edition, device templates, Comtrade Viewer, electronic manual included as well as “Getting started” manual on paper, connecting cables (copper)	
Basis Full version with license for 10 computers, on CD-ROM (authorization by serial number)	7XS5400-0AA00
Professional Basis and all optional packages on CD-ROM, DIGSI 4 and DIGSI 3	7XS5402-0AA00
Copper connecting cable	
Cable between PC/notebook (9-pin connector) and protection unit (9-pin connector) (contained in DIGSI 4, but can be ordered additionally)	7XV5100-4
Manual	
7VE61 and 7VE63 Multifunction Paralleling Device	C53000-G1176-C163-1

Fig. 11/99
Short-circuit links for voltage contacts

Fig. 11/100
Mounting rail for 19" rack

Description		Order No.	Size of package	Supplier
Crimp connector	CI2 0.5 to 1 mm^2	0-827039-1	4000	AMP 1)
		0-827396-1	1	AMP 1)
	CI2 1 to 2.5 mm^2	0-827040-1	4000	AMP 1)
		0-827397-1	1	AMP 1)
	Type III+ 0.75 to 1.5 mm^2	0-163083-7	4000	AMP 1)
		0-163084-2	1	AMP 1)
Crimping tool	for type III+	0-539635-1	1	AMP 1)
	and matching female	0-539668-2		AMP 1)
	for CI2	0-734372-1	1	AMP 1)
	and matching female	1-734387-1		AMP 1)
19"-mounting rail		C73165-A63-D200-1	1	Siemens
Short-circuit links	For voltage terminals	C73334-A1-C34-1	1	Siemens
Safety cover for terminals	large	C73334-A1-C31-1	1	Siemens
	small	C73334-A1-C32-1	1	Siemens

1) Your local Siemens representative can inform you on local suppliers.

Connection diagram

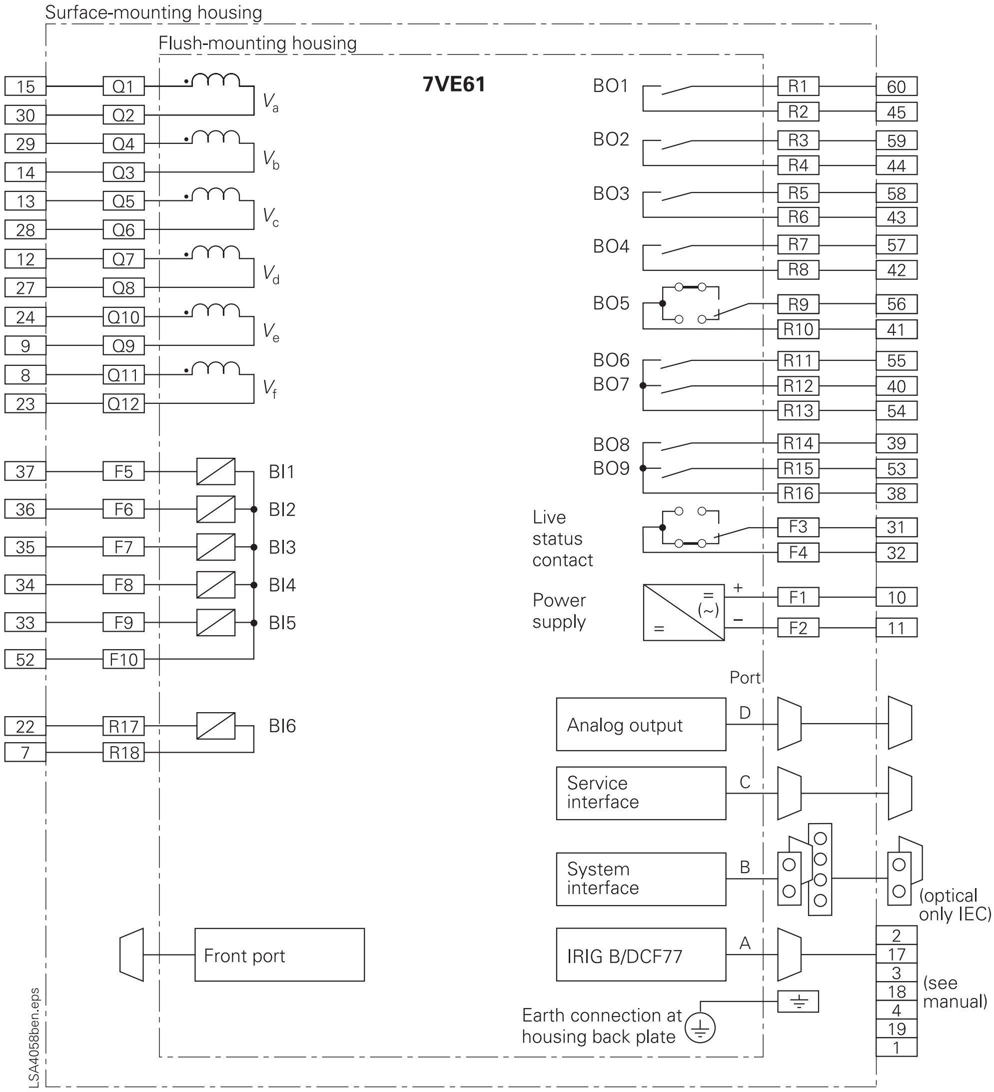


Fig. 5/101
Connection diagram

Connection diagram

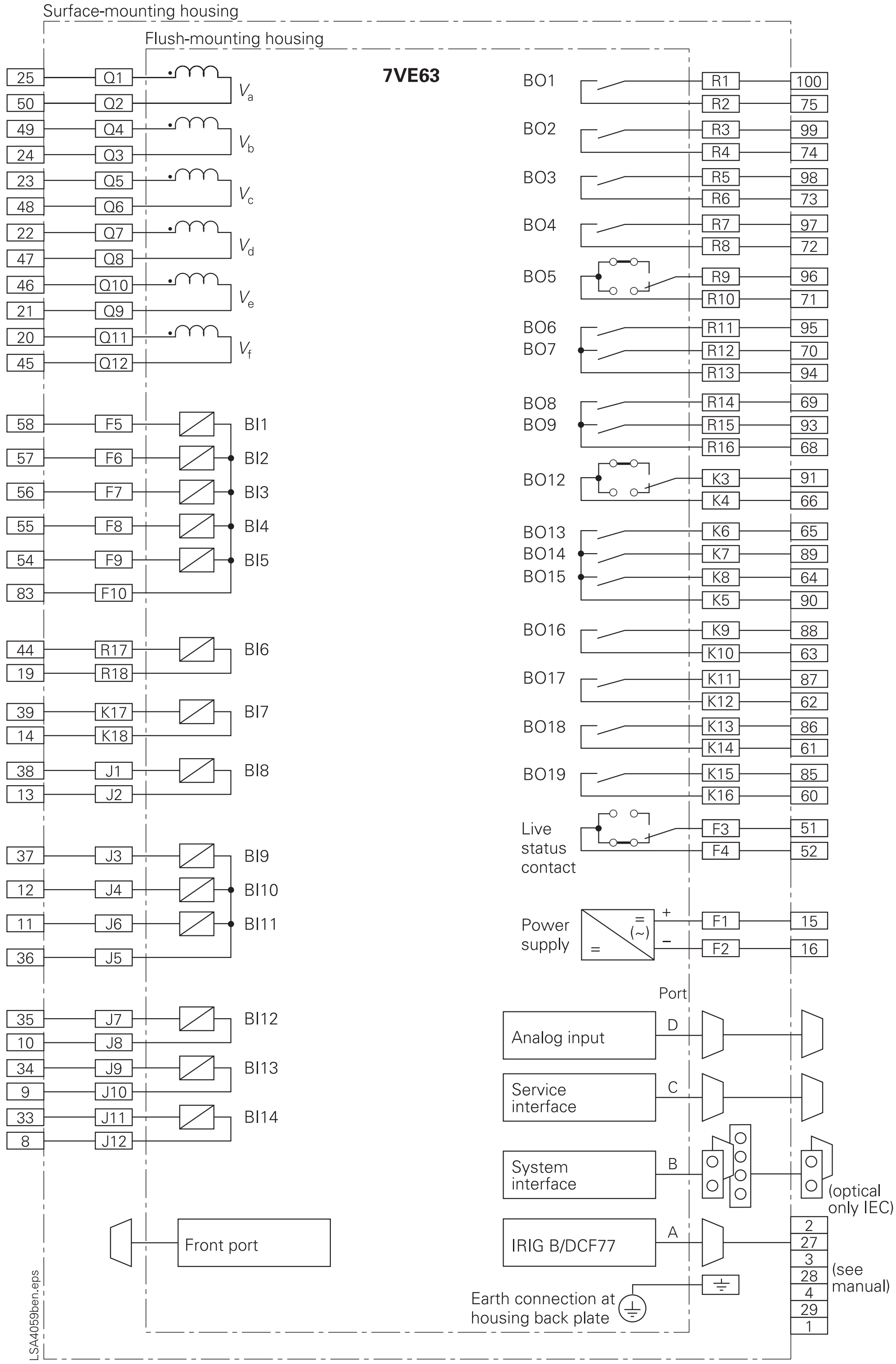


Fig. 5/102
Connection diagram

11

Motor Protection

Application

Comprehensive motor protection functions are available in our overcurrent relays and in the machine protection units. No separate relay family is required for this application.

The examples in part 2 illustrate that relay selection depends on the type and size of the motor and on the protection functions required (see Fig. 2/58 to 2/61).

The following table shows which motor protection functions are available in the different relays (partly, functions are optional).

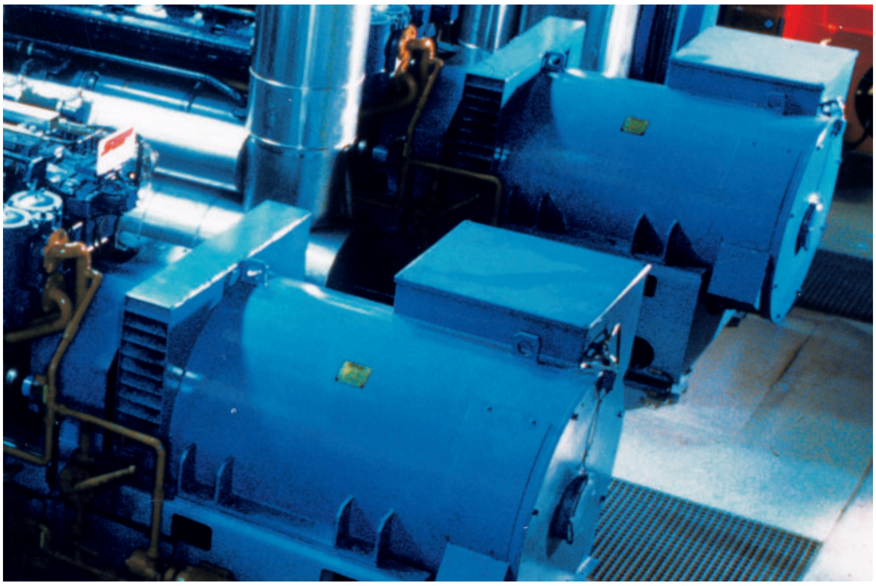


Fig. 12/1

Fault	Protection	ANSI No.
Stator thermal overload	Stator thermal overload protection	49
Rotor thermal overload during start too long or blocked too frequent	2 protection principles for the rotor overload protection Motor starting time supervision Restart inhibit	 48 66, 49R
Earth fault (ground fault)	Earth-fault protection (I_0>; V_0>;<(V_0, I_0))	50G, 64G, 67G
Short-circuit	Overcurrent-time protection Current differential protection	50, 51 87
Loss of phase	Negative-sequence protection (I_2/I_N)	46
Bearing overload	Temperature monitoring	38
Overheating of plant on unloaded drivers (pumps, compressors)	Undercurrent protection active-power protection (P<)	37, 32U
Undervoltage (starting torque not reached M ≈ V^2 or start too long)	Undervoltage protection	27
Asynchronous operation (of an asynchronous motor)	Underexcitation protection	40

Protection functions for various types of motor faults

Application

Protection functions	ANSI No.	7SJ600	7SJ602	7SJ61	7SJ62	7SJ63/64	7UM61	7UM62
Stator overload protection	49	■	■	■	■	■	■	■
Starting time supervision	48	■	■	■	■	■	■	■
Locked-rotor protection	48	■	■	■	■	■	■	■
Restart inhibit	66, 49R		■	■	■	■	■	■
Earth-fault protection								
non-directional	64G		■		■	■	■	■
	50G	■	■	■	■	■	■	■
directional	67G		■		■	■	■	■
Overcurrent-time protection	50, 51	■	■	■	■	■	■	■
Current differential protection	87							■
Negative-sequence protection	46	■	■	■	■	■	■	■
Temperature monitoring (via thermo-box)	38		■		■	■	■	■
Undercurrent protection	37		■	■	■	■	■	■
Active-power protection (P<)	32U (37)						■	■
Undervoltage protection	27				■	■	■	■
Underexcitation protection	40						■	■
Frequency protection	81				■	■	■	■
Breaker-failure protection	50BF		■	■	■	■	■	■
Freely programmable logic (PLC)				■	■	■	■	■
Control functions		■	■	■	■	■	■	■
Measuring transducers						■		■
Flexible serial interfaces		–	1	2	2	2/3	2	3

Scope of motor protection functions provided by SIPROTEC devices

Selection table

Asynchronous motor		Synchronous motor	
100 kW - 500 kW		**< 2 MW**	
7SJ60 Basic device	**7SJ61** + more I/Os + control functions + flexible serial interfaces + better local HMI (4-line display; digital keyboard)	**7UM61** (Option: Generator Basic)	
500 kW - (1-2) MW		**< 10 MW**	
7SJ62 Basic device + control functions	**7UM61** + more I/Os (7UM612) + control functions + high accuracy + high sensitivity + operating range in a wide frequency band (11 Hz - 68 Hz)	**7UM62** (Option: Generator Basic)	
or with control functions via bay mimic diagram in graphic display			
7SJ63 Basic device	**7SJ64** + synchro-check function + high sensitivity + extensive control function + 1 serial interface more		
> 2 MW		**> 10 MW**	
	7UM62 + differential protection + control functions + high accuracy + high sensitivity + operating range in a wide frequency band (11 Hz - 68 Hz)	**7UM62** (Option: Generator Basic)	**+ 7UM61** (Option: Generator Basic) or with control functions via bay mimic diagram in graphic display **+ 7SJ64** (Option: Maximum functionality + synchro-check)

Application

Application example: Protection of a small motor 100 kW - 500 kW

7SJ600

- Stator thermal overload protection 49
- Starting time supervision 48
- Earth(ground)-fault protection 50G
- Overcurrent-time protection 50, 51
- Negative-sequence protection 46

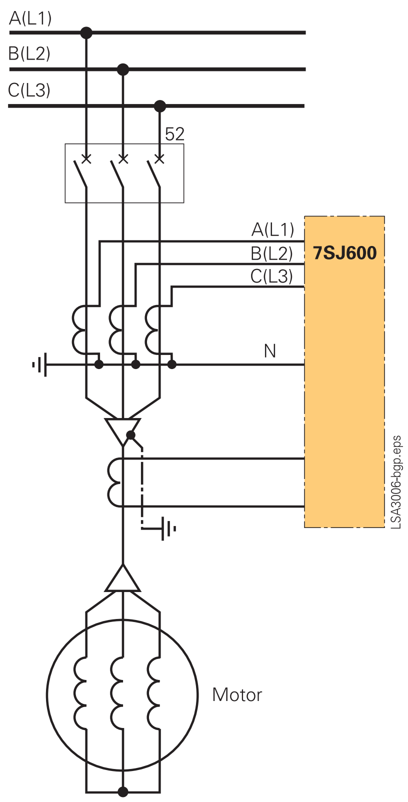


Fig. 12/2

Application example: Protection of a small motor 100 kW - 500 kW in solidly or low-resistance earthed (grounded) systems

7SJ602

- Overcurrent-time protection 50, 51
- Earth (ground)-fault protection, nondirectional 50G
- Negative-sequence protection 46
- Stator thermal overload protection 49
- Restart inhibit (rotor protection) 66, 49R
- Starting time supervision 48
- Undercurrent monitoring 37
- Breaker-failure protection 50BF
- External temperature monitoring box (thermo-box) 38

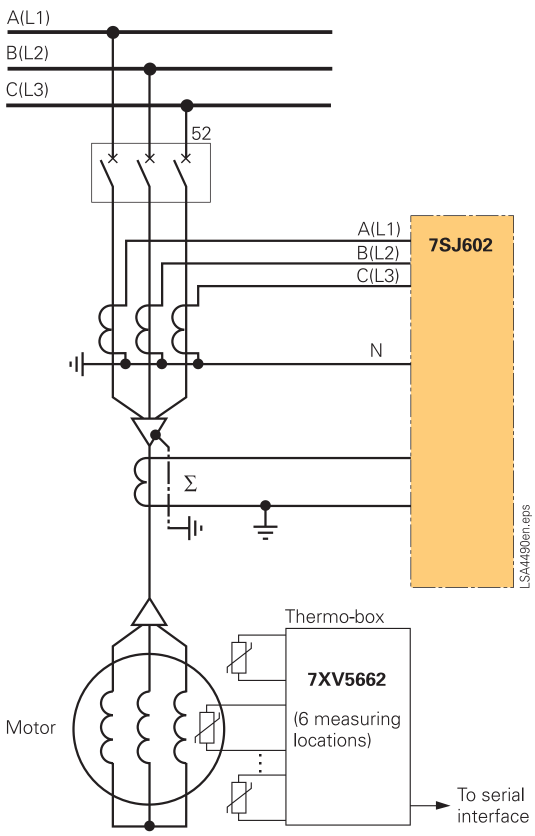


Fig. 12/3

Application

Application example: Protection of a small motor 100 kW - 500 kW in isolated or compensated systems

7SJ602

• Overcurrent-time protection	50, 51
• Sensitive earth (ground) fault (non-directional, directional)	50G 64G 67G
• Negative-sequence protection	46
• Stator thermal overload protection	49
• Restart inhibit (rotor protection)	66, 49R
• Starting time supervision	48
• Undercurrent monitoring	37
• Breaker-failure protection	50BF
• External temperature monitoring box (thermo-box)	38

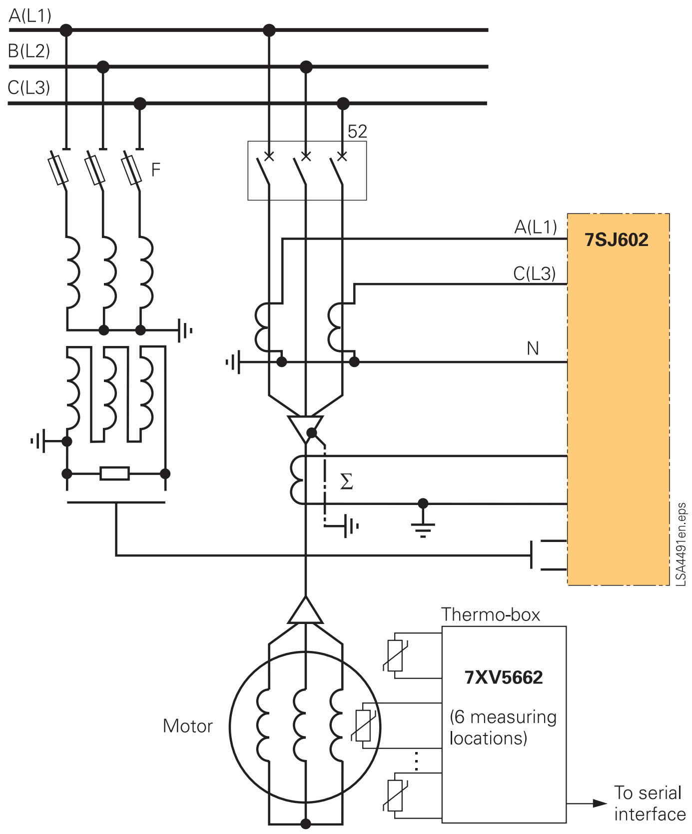


Fig. 12/4

Application

Application example: Protection of a medium-sized motor 500 kW - (1-2) MW

7SJ62/63

• Stator thermal overload protection	49
• Restart inhibit (rotor protection)	66, 49R
• Starting time supervision	48
• Earth-fault protection (non-directional, directional)	50G 64G 67G
• Overcurrent-time protection	50, 51
• Negative-sequence protection	46
• Undervoltage protection	27
• Undercurrent protection	37
• Breaker-failure protection	50BF
• External temperature monitoring box (thermo-box)	38

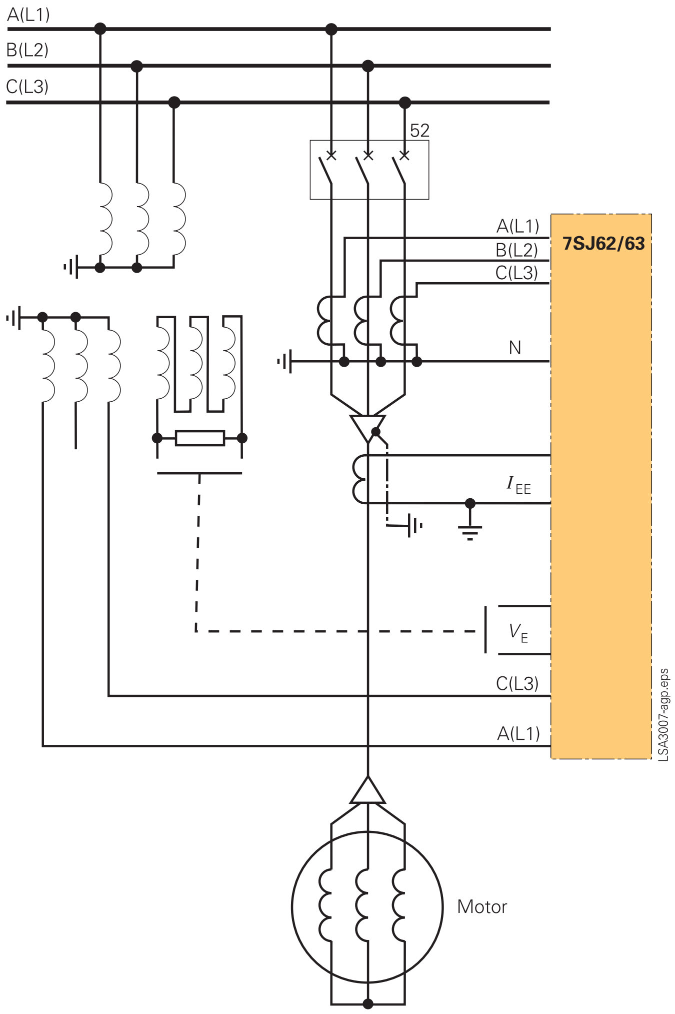


Fig. 12/5

Application

Application example: Protection of a large motor > 2 MW

7UM62

- Stator thermal overload protection 49
- Restart inhibit (rotor protection) 66, 49R
- Starting time supervision 48
- Earth-fault protection (non-directional, directional) 50G 64G 67G
- Differential protection 87M
- Overcurrent-time protection 50, 51
- Negative-sequence protection 46
- Undervoltage protection 27
- Undercurrent protection 37
- Active-power protection 32U
- Frequency protection 81
- Breaker-failure protection 50BF

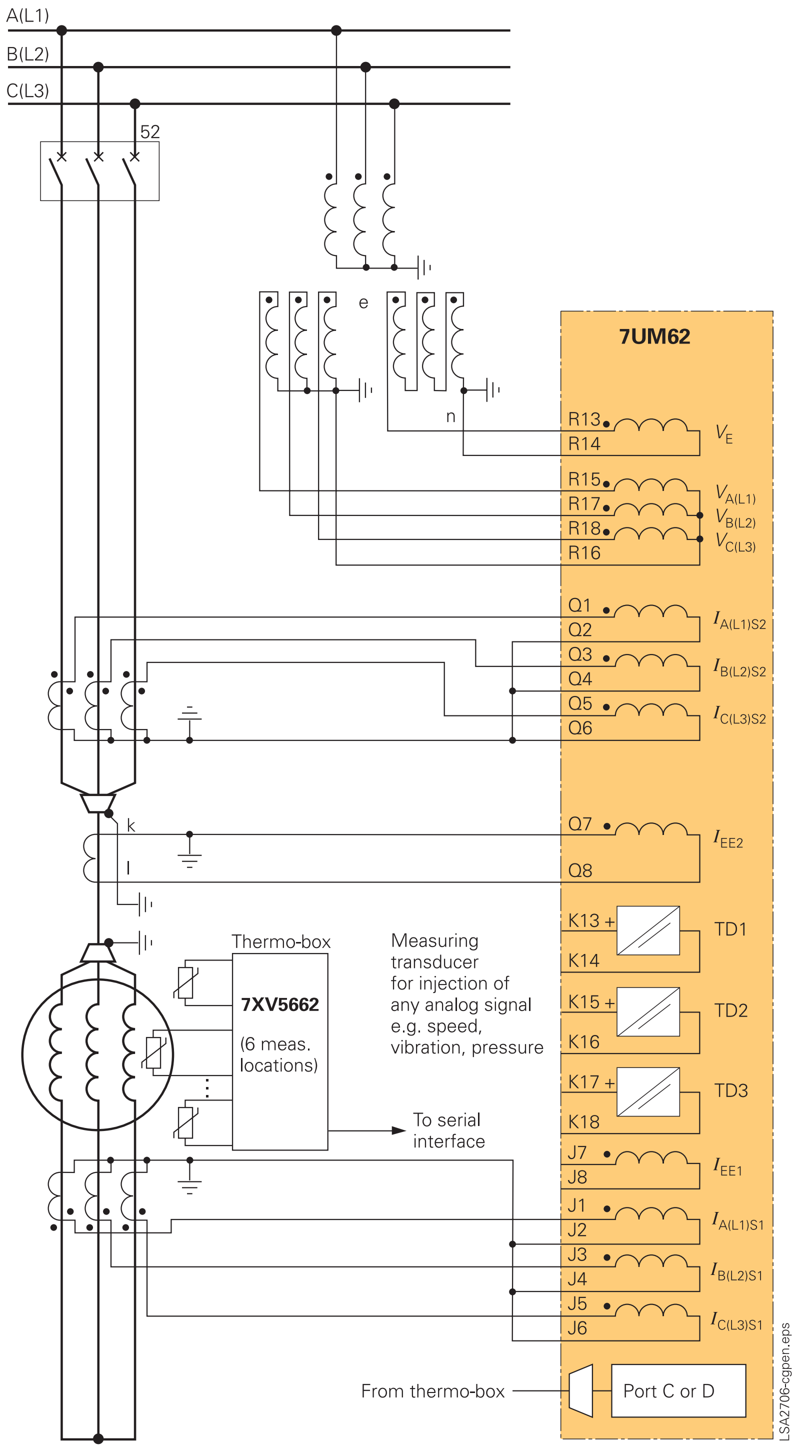
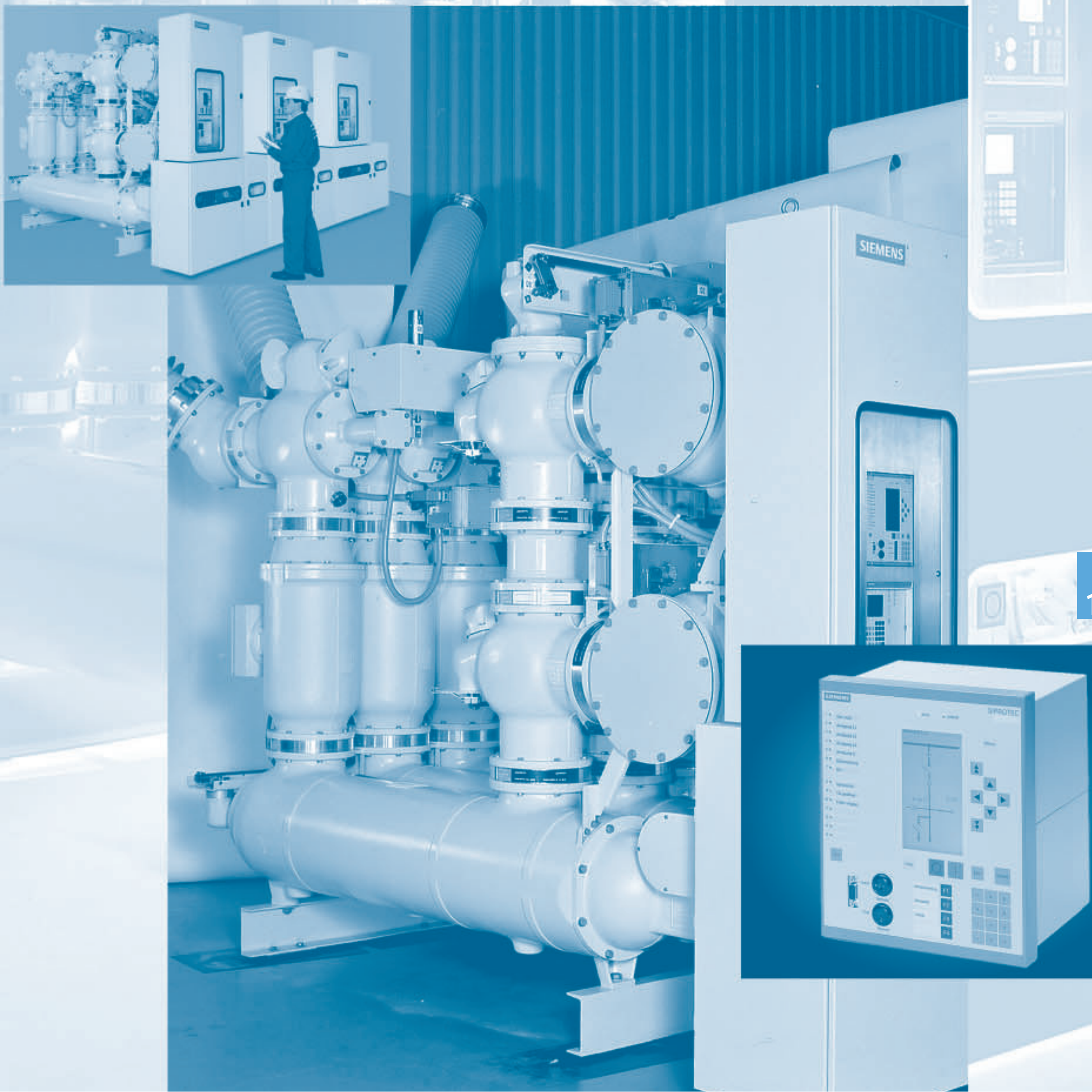


Fig. 12/6

Substation Control & Power Quality



13

SIPROTEC 4 6MD63
Bay Control Unit

LSP2314-afp.tif

Fig. 13/1
SIPROTEC 4
6MD63 bay control unit

Description

The 6MD63 bay control unit is a flexible, easy-to-use control unit. It is optimally tailored for medium-voltage applications but can also be used in high-voltage substations.

The 6MD63 bay control unit has the same design (look and feel) as the other protection and combined units of the SIPROTEC 4 relay series. Configuration is also performed in a standardized way with the easy-to-use DIGSI 4 configuration tool .

For operation, a large graphic display with a keyboard is available. The important operating actions are performed in a simple and intuitive way, e.g. alarm list display or switchgear control. The operator panel can be mounted separately from the relay, if required. Thus, flexibility with regard to the mounting position of the unit is ensured.

Integrated key-operated switches control the switching authority and authorization for switching without interlocking.

Function overview

Application

- Optimized for connection to three-position disconnectors
- Switchgear interlocking interface
- Suitable for redundant master station
- Automation can be configured easily by graphic means with CFC

Control functions

- Number of switching devices only limited by number of available inputs and outputs
- Position of switching elements is shown on the graphic display
- Local/remote switching via key switch
- Command derivation from an indication
- 4 freely assignable function keys to speed up frequently recurring operator actions
- Switchgear interlocking isolator/c.-b.
- Key-operated switching authority
- Feeder control diagram
- Measured-value acquisition
- Signal and command indications
- P, Q, cos φ (power factor) and meter-reading calculation
- Event logging
- Switching statistics

Monitoring functions

- Operational measured values
- Energy metering values
- Time metering of operating hours
- Slave pointer
- Self-supervision of relay

Communication interfaces

- System interface
  - IEC 61850 Ethernet
  - IEC 60870-5-103 protocol
  - PROFIBUS-FMS
  - DNP 3.0
  - PROFIBUS-DP
  - MODBUS
  - Service interface for DIGSI 4 (modem)/temperature detection (thermo-box)
  - Front interface for DIGSI 4
  - Time synchronization via IRIG-B/DCF 77

Selection and ordering data

Description	Order No.	Order code
6MD63 bay control unit with local control	*6MD63□□ – □□□□□ – □AA0*	*□□□*
Housing, binary inputs (BI) and outputs (BO), measuring transducer		
Housing ½ 19”, 11 BI, 8 BO, 1 live status contact	1	
Housing ½ 19”, 24 BI, 11 BO, 4 power relays, 1 live status contact	2	
Housing ½ 19”, 20 BI, 11 BO, 2 measuring transducer inputs, 4 power relays, 1 live status contact	3	
Housing ½ 19”, 20 BI, 6 BO, 4 power relays, 1 live status contact	4 1)	
Housing 1/1 19”, 37 BI, 14 BO, 8 power relays, 1 live status contact	5	
Housing 1/1 19”, 33 BI, 14 BO, 2 measuring transducer inputs, 8 power relays, 1 live status contact	6	
Housing ½ 19”, 33 BI, 9 BO, 8 power relays, 1 live status contact	7 1)	
Current transformer I_n		
No analog measured variables	0	
1 A 2)	1	
5 A 2)	5	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V 3)	2	
60 to 125 V DC 4), threshold binary input 19 V 3)	4	
110 to 250 V DC 4), 115 to 230 V AC, threshold binary input 88 V 3)	5	
Unit design		
For panel surface mounting, plug-in terminal, detached operator panel	A	
For panel surface mounting, 2-tier terminal, top/bottom	B	
For panel surface mounting, screw-type terminal, detached operator panel	C	
For panel flush mounting, plug-in terminal (2/3 pin AMP connector)	D	
For panel flush mounting, screw-type terminal (direct connection/ring-type cable lugs)	E	
For panel surface mounting, screw-type terminal (direct connection / ring-type cable lugs), without HMI	F	
For panel surface mounting, plug-in terminal without HMI	G	
Region-specific default settings/function versions and language settings		
Region DE, 50 Hz, IEC, language: German, changeable	A	
Region World, 50/60 Hz, IEC/ANSI, language: English (GB), changeable	B	
Region US, 60 Hz, ANSI, language: English (US), changeable	C	
Region FR, IEC/ANSI, language: French, changeable	D	
Region World, IEC/ANSI, language: Spanish, changeable	E	
System interface (on rear of unit/Port B)		
No system port	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, 820 nm fiber optic, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, fiber optic, single ring, ST connector 5)	5	
PROFIBUS-FMS Slave, fiber optic, double ring, ST connector 5)	6	
PROFIBUS-DP Slave, RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm fiber optic, double ring, ST connector 5)	9	L 0 B
MODBUS, RS485	9	L 0 D
MODBUS, 820 nm fiber optic, ST connector 5)	9	L 0 E
DNP 3.0, RS485	9	L 0 G
DNP 3.0, 820 nm fiber optic, ST connector 5)	9	L 0 H
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector 5)	9	L 0 S
DIGSI 4/modem interface (on rear of unit/Port C)		
No port on rear side	0	
DIGSI 4, electrical RS232	1	
DIGSI 4, electrical RS485	2	
DIGSI 4, optical 820 nm, ST connector	3	
Measuring		
Basic metering (current, voltage)	0	
Slave pointer, mean values, min/max values only for position 7= 1 and 5	2	

1) Only for position 7 = 0
2) Rated current can be selected by means of jumpers.
3) The binary input thresholds can be selected in two stages by means of jumpers.
4) Transition between the two auxiliary voltage ranges can be selected by means of jumpers.
5) Not with position 9 = “B”; if 9 = “B”; please order 6MD6 unit with RS485 port and separate fiber-optic converter.

13

SIPROTEC 4 6MD66
High-Voltage Bay Control Unit

LSP2187-afp.eps

Fig. 13/2 SIPROTEC 4
6MD66 high-voltage bay control unit

Description

The 6MD66 high-voltage bay control unit is the control unit for high voltage bays from the SIPROTEC 4 relay series. Because of its integrated functions, it is an optimum, low-cost solution for high-voltage switchbays.

The 6MD66 high-voltage bay control unit also has the same design (look and feel) as the other protection and combined units of the SIPROTEC 4 relay series. Configuration is performed in a standardized way with the easy-to-use DIGSI 4 configuration tool.

For operation, a large graphic display with a keyboard is available. The important operating actions are performed in a simple and intuitive way, e.g. alarm list display or switchgear control. The operator panel can be mounted separately from the unit, if required. Thus, flexibility with regard to the mounting position of the unit is ensured. Integrated key-operated switches control the switching authority and authorization for switching without interlocking. High-accuracy measurement (± 0.5 %) for voltage, current and calculated values *P* and *Q* are another feature of the unit.

Function overview

Application

- Integrated synchro-check for synchronized closing of the circuit-breaker
- Automation can be configured easily by graphic means with CFC
- Flexible, powerful measured-value processing
- Connection for 4 voltage transformers, 3 current transformers, two 20 mA transducers
- Volume of signals for high voltage
- Up to 14 1 ½-pole circuit-breakers can be operated
- Up to 11 2-pole switching devices can be operated
- Up to 65 indication inputs, up to 45 command relays
- Can be supplied with 3 volumes of signals as 6MD662 (35 indications, 25 commands), 6MD663 (50 indications, 35 commands) or 6MD664 (65 indications, 45 commands); number of measured values is the same
- Switchgear interlocking
- Inter-relay communication with other devices of the 6MD66 series, even without a master station interface with higher level control and protection
- Suitable for redundant master station
- Display of operational measured values $V, I, P, Q, S, f, \cos\varphi$ (power factor) (single and three-phase measurement)
- Limit values for measured values
- Can be supplied in a standard housing for cubicle mounting or with a separate display for free location of the operator elements
- 4 freely assignable function keys to speed up frequently recurring operator actions

Communication interfaces

- System interface
  – IEC 61850 Ethernet
  – IEC 60870-5-103 protocol
  – PROFIBUS-FMS/-DP
  – Service interface for DIGSI 4 (modem)
  – Front interface for DIGSI 4
  – Time synchronization via IRIG B/DCF 77

13

Functions

Communication

With regard to communication between components, particular emphasis is placed on the SIPROTEC 4 functions required for energy automation.

- Every data item is time-stamped at its source, i.e. where it originates.
- Information is marked according to where it originates from (e.g. if a command originates "local" or "remote")
- The feedback to switching processes is allocated to the commands.
- Communication processes the transfer of large data blocks, e.g. file transfers, independently.
- For the reliable execution of a command, the relevant signal is first acknowledged in the unit executing the command. A check-back indication is issued after the command has been enabled (i.e. interlocking check, target = actual check) and executed.

In addition to the communication interfaces on the rear of the unit, which are equipped to suit the customer's requirements, the front includes an RS232 interface for connection of DIGSI. This is used for quick diagnostics as well as for the loading of parameters. DIGSI 4 can read out and represent the entire status of the unit online, thus making diagnostics and documentation more convenient. It is in principle possible to implement other communication protocols upon request.

Control

The bay control units of the 6MD66 series have command outputs and indication inputs that are particularly suited to the requirements of high-voltage technology. As an example, the 2-pole control of a switching device is illustrated (see Fig. 13/3). In this example, two poles of the circuit- breaker are closed and 1 pole is open. All other switching devices (disconnectors, earthing switches) are closed and open in 1½-pole control. A maximum of 14 switching devices can be controlled in this manner.

A complete 2-pole control of all switching devices (see Fig. 13/4) is likewise possible. However more contacts are required for this. A maximum of 11 switching devices can be controlled in this manner.

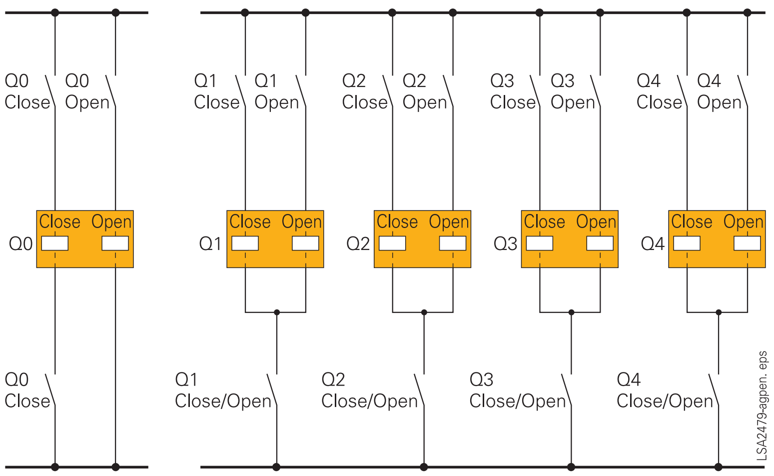


Fig. 13/3 Connection diagram of the switching devices (circuit-breaker 2 poles closed, 1 pole open; disconnector/earthing switch 1½ pole)

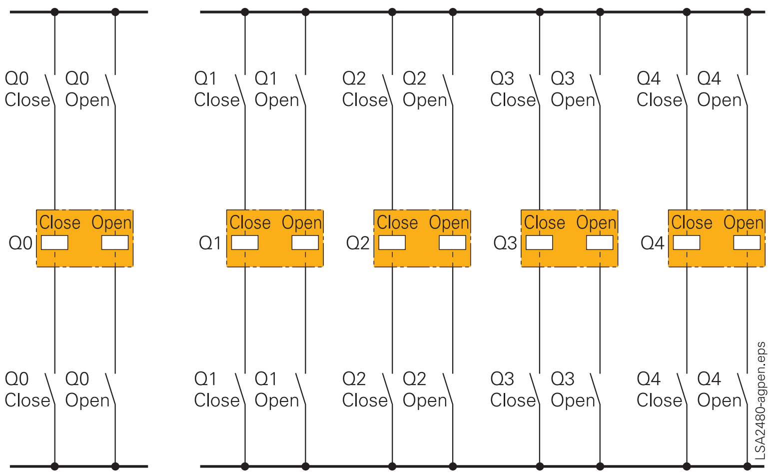


Fig. 13/4 2-pole connection diagram of circuit-breakers and disconnectors

A possible method to connect the switching devices to the bay control unit 6MD66 is shown in Fig 13/5. There it is shown how three switching devices Q0, Q1, and Q2 are connected using 1½ pole control.

Functions

Switchgear interlockings

Using the CFC (Continuous Function Chart) available in all SIPROTEC 4 units, the bay interlock conditions can, among other things, be conveniently configured graphically in the 6MD66 bay control unit. The inter-bay interlock conditions can be checked via the “inter-relay communication” (see next section) to other 6MD66 devices. With the introduction of IEC 61850 communication, the exchange of information for interlocking purposes is also possible via Ethernet. This is handled via the GOOSE message method. Possible partners are all other bay devices or protection devices which support IEC 61850-GOOSE message.

In the tests prior to command output, the positions of both key-operated switches are also taken into consideration. The upper key-operated switch corresponds to the S5 function (local/remote switch), which is already familiar from the 8TK switchgear interlock system. The lower key-operated switch effects the changeover to non-interlocked command output (S1 function). In the position ”Interlocking Off” the key cannot be withdrawn, with the result that non-operation of the configured interlocks is immediately evident.

The precise action of the key-operated switch can be set using the parameter ”switching authority”.

With the integrated function ”switchgear interlocking” there is no need for an external switchgear interlock device.

Furthermore, the following tests are implemented (parameterizable) before the output of a command:

- Target = Actual, i.e. is the switching device already in the desired position?
- Double command lockout, i.e. is another command already running?
- Individual commands, e.g. earthing control can additionally be secured using a code.

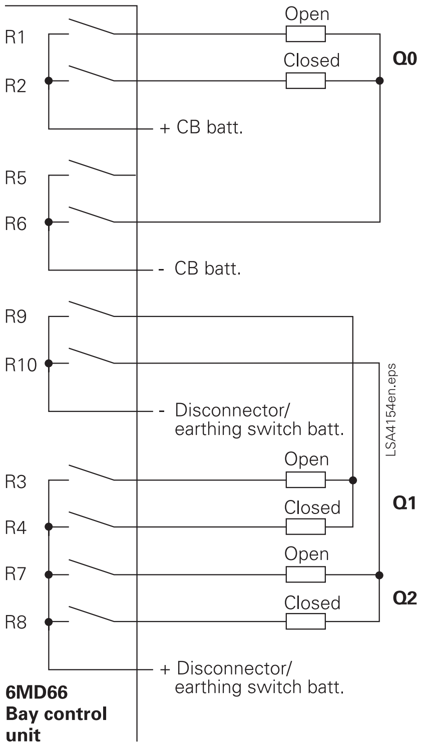


Fig. 13/5
Typical connection for 1½-pole control

13

Functions

Synchronization

The bay control unit can, upon closing of the circuit-breaker, check whether the synchronization conditions of both partial networks are met (synchrocheck). Thus an additional, external synchronization device is not required. The synchronization conditions can be easily specified using the configuration system DIGSI 4. The unit differentiates between synchronous and asynchronous networks and reacts differently upon connection:

In synchronous networks there are minor differences with regard to phase angle and voltage moduli and so the circuit-breaker response time does not need to be taken into consideration. For asynchronous networks however, the differences are larger and the range of the connection window is traversed at a faster rate. Therefore it is wise here to take the circuit-breaker response time into consideration. The command is automatically dated in advance of this time so that the circuit-breaker contacts close at precisely the right time. Fig. 13/6 illustrates the connection of the voltages.

As is evident from Fig. 13/6, the synchronization conditions are tested for one phase. The important parameters for synchronization are:

$|U_{min}| < |U| < |U_{max}|$
(Voltage modulus)

$\Delta\varphi < \Delta\varphi_{max}$
(Angle difference)

$\Delta f < \Delta f_{max}$
(Frequency difference)

Using the automation functions available in the bay control unit, it is possible to connect various reference voltages depending on the setting of a disconnector. Thus in the case of a double busbar system, the reference voltage of the active busbar can be automatically used for synchronization (see Fig. 13/7).

Alternatively the selection of the reference voltage can also take place via relay switching, if the measurement inputs are already being used for other purposes.

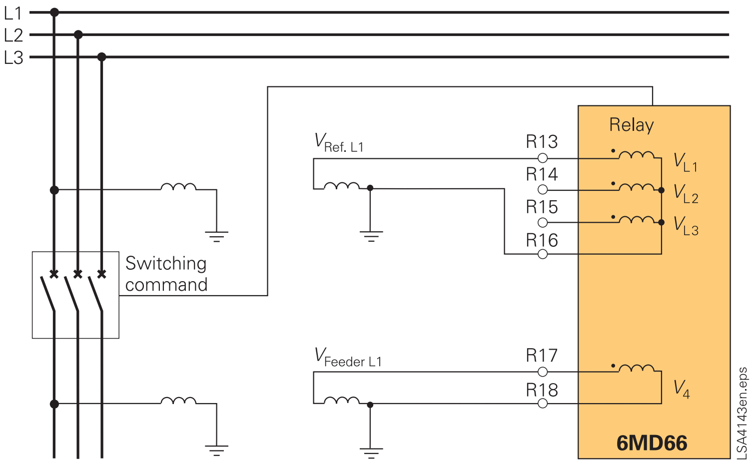


Fig. 13/6
Connection of the measured values for synchronization

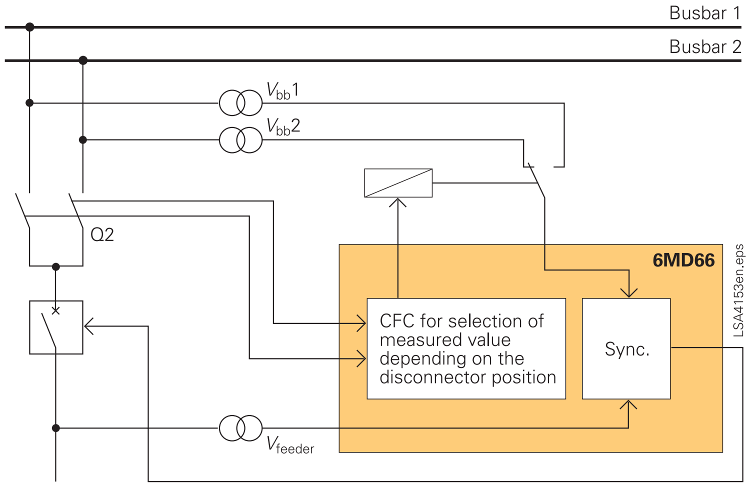


Fig. 13/7
Voltage selection for synchronization with duplicate busbar system

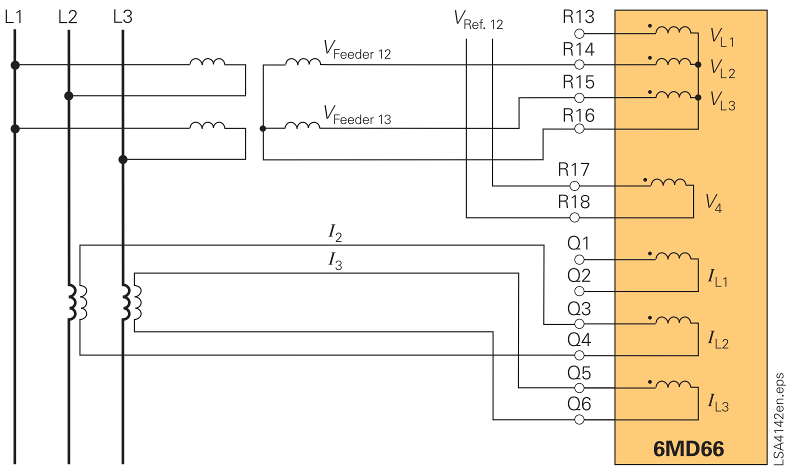


Fig. 13/8
Simultaneous connection of measured values according to a two-wattmeter circuit and synchronization

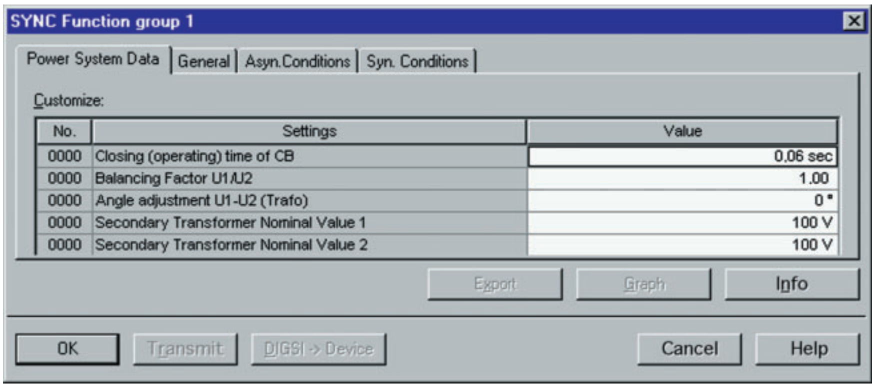
Functions

Synchronization

The bay control unit offers the option of storing various parameter sets (up to eight) for the synchronization function and of selecting one of these for operation. Thus the different properties of several circuit-breakers can be taken into consideration. These are then used at the appropriate time. This is relevant if several circuit-breakers with e.g. different response times are to be served by one bay control unit.

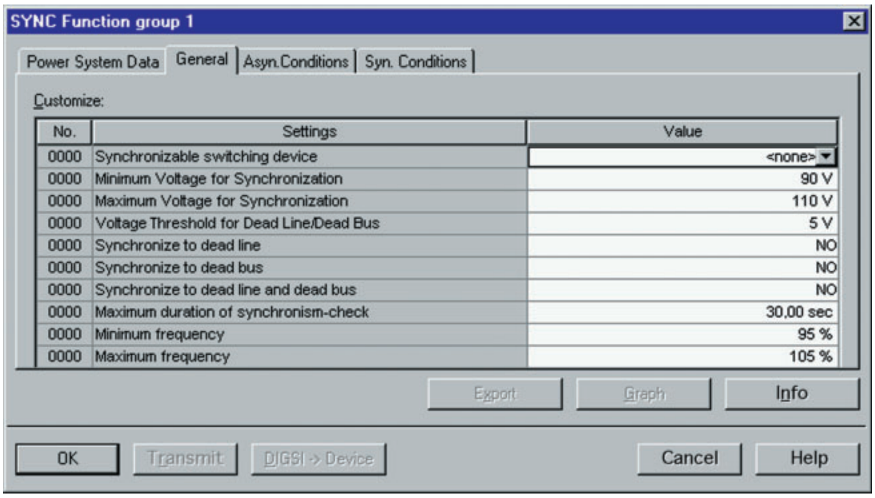
The measured values can be connected to the bay control unit in accordance with Fig. 13/6 (single-phase system) or Fig. 13/8 (two-wattmeter circuit).

The synchronization function can be parameterized via four tabs in DIGSI.



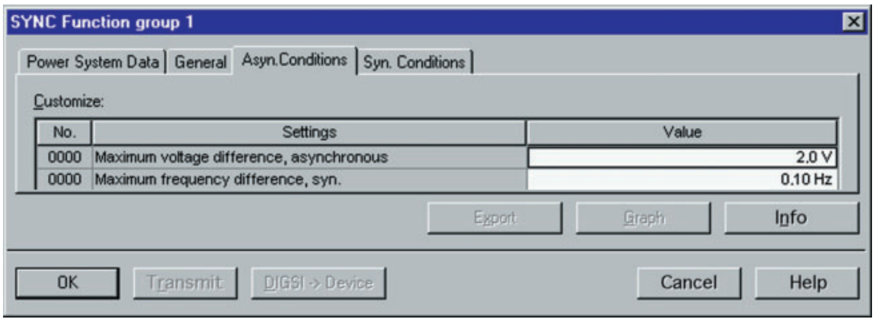
LSP2493en.tif

Fig. 13/9
"Power System Data", sheet for parameters of the synchronizing function



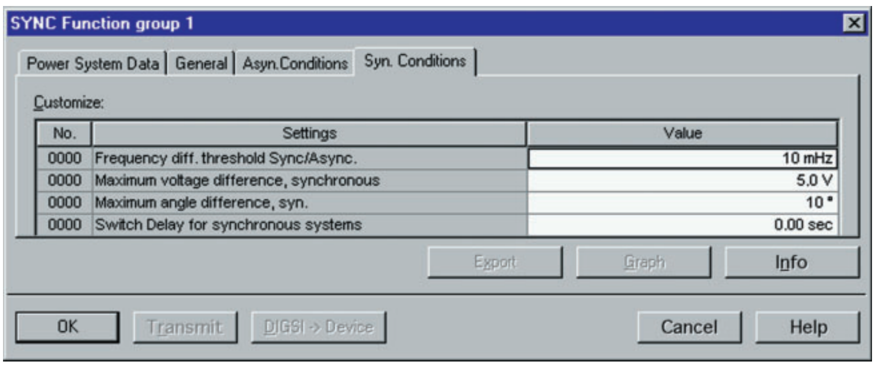
LSP2496en.tif

Fig. 13/10
General parameters of the synchronization function



LSP2494en.tif

Fig. 13/11
Parameter page for asynchronous networks



LSP2495en.tif

Fig. 13/12
Parameter page for asynchronous networks

13

Communication

Inter-relay communication

The function "inter-relay communication" enables the exchange of information between the bay control units without the intervention of the substation controller (SC) being required. To this end, the units are connected to each other via an RS485 connection or via an external converter and a fiber-optics transmission system (see Fig. 13/13).

One situation where inter-relay communication comes into play are the interlock conditions within a bay featuring the 1½ circuit-breaker method, which is operated using three bay control units (see Fig. 13/14). With the 1½ circuit-breaker method, a bay control unit is allocated to every circuit-breaker. As a result, the redundancy on the primary side (even if one circuit-breaker fails, both feeders still have to be supplied) is also supported by a redundancy on the secondary (control) side. Control over the entire bay is retained, even if one of the bay control units fails. If the connection to the master unit or the master unit itself is disturbed, control is still possible with the interlocking in operation, by means of the inter-relay communication. Inter-relay communication is likewise configured using DIGSI 4. To this end, a network of units is created, which provides a logic matrix. The information which the stations are to exchange is assigned in this logic matrix. The information from the coupling (6MD664 unit IGK2 coupling) is available for use in the feeder (assignment to 6MD663 unit IRC1 feeder as target). In this way, the information from the feeder unit can be used in the coupling unit. The connection matrix contains all information which has inter-relay communication as the source or the target (column "R") in the DIGSI 4 configuration matrix.

GOOSE

With the new communication standard IEC 61850, a similar function like IRC is provided with the "GOOSE" communication to other IEC 61850 devices. So GOOSE also enables the exchange of interlocking data between the bay control units. The communication is performed via the substation Ethernet.

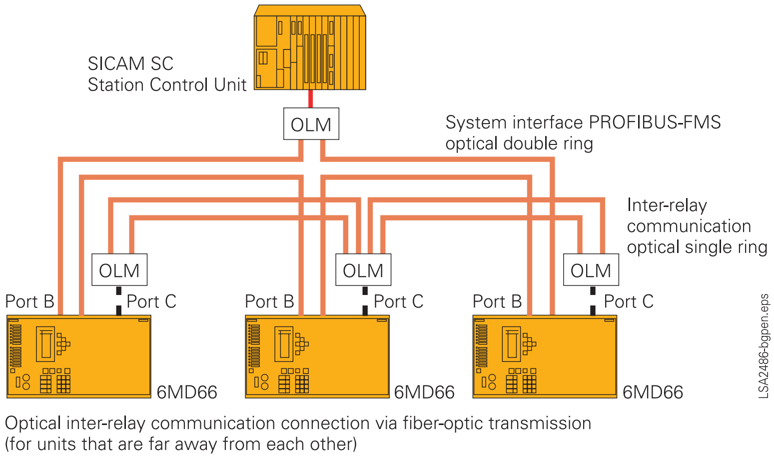


Fig. 13/13 Bay control unit connection for inter-relay communication (optical)

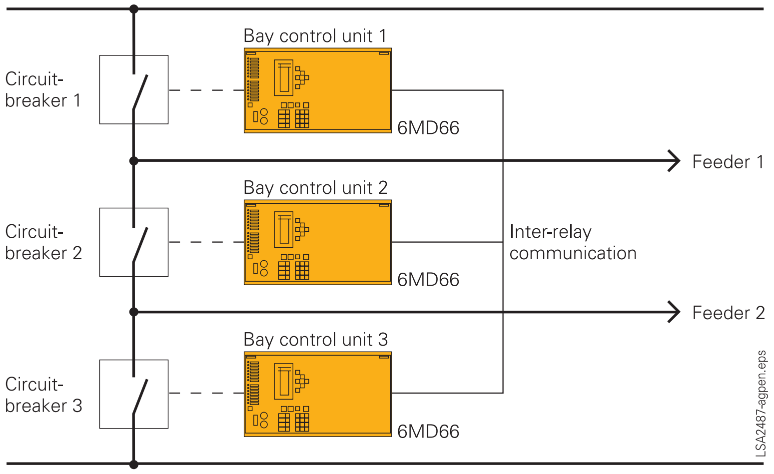
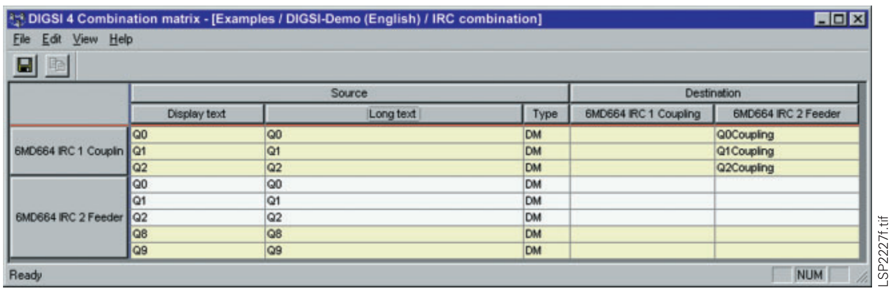


Fig. 13/14 Typical application: 1½ circuit-breaker method (disconnector and earthing switch not shown)


DIGSI 4 Combination matrix - [Examples / DIGSI-Demo (English) / IRC combination]

File Edit View Help

	Source			Destination	
	Display text	Long text	Type	6MD664 IRC 1 Coupling	6MD664 IRC 2 Feeder
6MD664 IRC 1 Couplin	Q0	Q0	DM		Q0Coupling
	Q1	Q1	DM		Q1Coupling
	Q2	Q2	DM		Q2Coupling
6MD664 IRC 2 Feeder	Q0	Q0	DM		
	Q1	Q1	DM		
	Q2	Q2	DM		
	Q8	Q8	DM		
	Q9	Q9	DM		

Ready NUM

LSP2227f.tif

Fig. 13/15
Connection matrix of inter-relay communication in DIGSI 4

13

Functions

Measured value processing

Measured value processing is implemented by predefined function modules, which are likewise configured using DIGSI 4.

The transducer modules are assigned in the DIGSI 4 assignment matrix to current and voltage channels of the bay control unit. From these input variables, they form various computation variables (see Table 13/1).

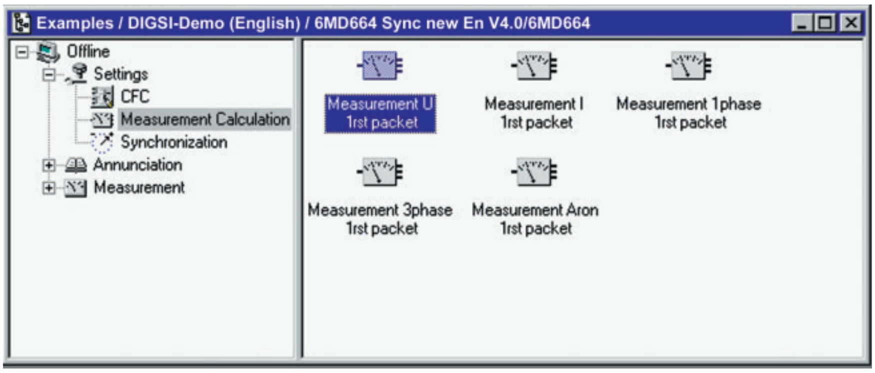


Fig. 13/16
DIGSI 4 Parameter view - transducer packages

The individual transducer modules can be activated in the functional scope of the unit and will then appear in the DIGSI 4 assignment matrix with the input channels and output variables from Table 1. The output variables can then be assigned to the system interface or represented in the measured value window in the display.

Name of the transducer module	Max. availability of transducers on the unit (can be set via the functional scope)	Required input channels	Calculated variables (= output variables)
Transducer V	x 1	V	V, f
Transducer I	x 1	I	I, f
Transducer 1 phase	x 3	V, I	V, I, P, Q, S, φ, cos φ (PF), sin φ, f
Transducer 3 phase	x 1	$V1$, $V2$, $V3$, $I1$, $I2$, $I3$	$V0$, $V1$, $V2$, $V3$, $V12$, $V23$, $V31$, $I0$, $I1$, $I2$, $I3$, P, Q, S, φ, cos φ (PF), sin φ, f
Transducer two-wattmeter circuit	x 1	$V1$, $V2$, $I1$, $I2$	$V12$, $V13$, $I2$, $I3$, P, Q, S, φ, cos φ (PF), sin φ, f

Table 13/1
Properties of measured value processing

Sample presentation of the measured value display.

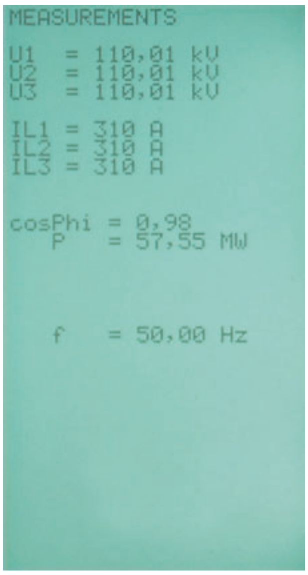


Fig. 13/17

13

Functions

The connection of the input channels can be chosen without restriction. For the two-wattmeter circuit, the interface connection should be selected in accordance with Fig. 13/18. The two-wattmeter circuit enables the complete calculation of a three-phase system with only two voltage and two current transformers.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the bay control unit can obtain and process metering pulses via an indication input.

The metered values can be displayed and passed on to a master unit. A distinction is made between forward, reverse, active and reactive power (± kWh, ± kvarh).

Automation

With integrated logic, the user can set, via a graphic interface (CFC, Continuous Function Chart), specific functions for the automation of switchgear or substation. Functions are activated via function keys, binary input or via communication interface. Processing of internal indications or measured values is also possible.

Switching authorization/ Key-operated switch

The switching authorization (control authorization) (interlocked/non-interlocked, corresponds to key-operated S1 in the 8TK interlock system) and the switching authority (local/remote, corresponds to key-operated S5 for 8TK) can be preset for the SIPROTEC 4 bay control unit using key-operated switches. The position of both keys is automatically evaluated by command processing. The key for operation without interlocks cannot be removed when in the position "non-interlocked", such that this mode of operation is immediately recognizable (see also page 13/7, Section "Switchgear interlockings").

Every change in the key-operated switch positions is logged.

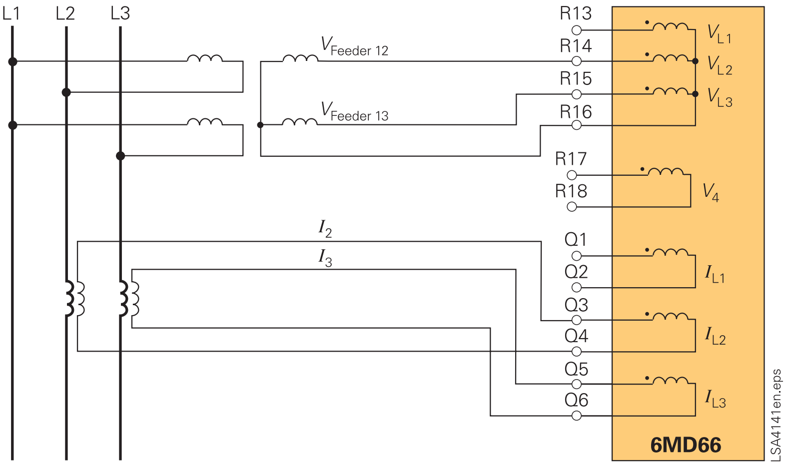


Fig. 13/18
Two-wattmeter circuit (connection to bay control unit)

Chatter blocking

Chatter blocking feature evaluates whether, in a configured period of time, the number of status changes of indication input exceeds a specified figure. If exceeded, the indication input is blocked for a certain period, so that the communication line to the master unit will not be overloaded by disturbed inputs.

For every binary input, it is possible to set separately whether the chatter blocking should be active or not. The parameters (number of status changes, test time, etc.) can be set once per unit.

Indication / measured value blocking

To avoid the transmission of information to the master unit during works on the bay, a transmission blocking can be activated.

Indication filtering

Indications can be filtered and delayed.

Filtering serves to suppress brief changes in potential at the indication input. The indication is passed on only if the indication voltage is still present after a set period of time.
The filter time can be set from 0 to 24 hours in 1 ms steps. It is also possible to set the filter time so that it can, if desired, be retriggered.

Furthermore, the hardware filter time can be taken into consideration in the time stamp; i.e. the time stamp of a message that is detected as arriving will be predated by the known, constant hardware filter time. This can be set individually for every message in a 6MD66 bay control unit.

Functions

Auto-Reclosure (ANSI 79)

The 6MD66 is equipped with an auto-reclosure function (AR). The function includes several operating modes:

- Interaction with an external device for auto-reclosure via binary inputs and binary outputs; also possible with interaction via IEC 61850-GOOSE
- Control of the internal AR function by external protection
- 3-pole auto-reclosure for all types of faults; different dead times are available depending on the type of the fault
- 1-pole auto-reclosure for 1-phase faults, no reclosing for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults, no reclosing for multi-phase faults.
- 1-pole auto-reclosure for 1-phase and 3-pole auto-reclosure for multi-phase faults
- 1-pole auto-reclosure for 1-phase faults and 2-phase faults and 3-phase auto-reclosure for multi-phase faults
- Multiple-shot auto-reclosure
- Interaction with the internal synchro-check
- Monitoring of the circuit-breaker auxiliary contacts

In addition to the above-mentioned operating modes, several other operating principles can be employed by means of the integrated programmable logic (CFC). Integration of auto-reclosure in the feeder protection allows the line-side voltages to be evaluated. A number of voltage-dependent supplementary functions are thus available:

- DLC
  By means of dead-line-check (DLC), reclosure is effected only when the line is deenergized (prevention of asynchronous breaker closure)
- ADT
  The adaptive dead time (ADT) is employed only if auto-reclosure at the remote station was successful (reduction of stress on equipment).
- RDT
  Reduced dead time (RDT) is employed in conjunction with auto-reclosure where no teleprotection method is employed: When faults within the zone extension but external to the protected line of a distance protection are switched off for rapid auto-reclosure (RAR), the RDT function decides on the basis of measurement of the return voltage from the remote station which has not tripped whether or not to reduce the dead time.

Breaker failure protection (ANSI 50BF)

The 6MD66 incorporates a two-stage circuit-breaker failure protection to detect failures of tripping command execution, for example, due to a defective circuit breaker. The current detection logic is phase-selective and can therefore also be used in single-pole tripping schemes. If the fault current is not interrupted after a settable time delay has expired, a retrip command or a busbar trip command will be generated. The breaker failure protection can be initiated by external devices via binary input signals or IEC 61850 GOOSE messages.

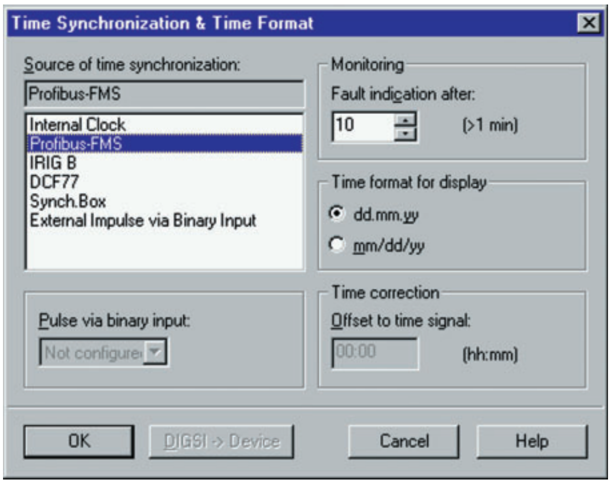


Fig. 13/19
Parameterization of time management

Time management

The 6MD66 bay control units can, like the other units in the SIPROTEC 4 range, be provided with the current time by a number of different methods:

- Via the interface to the higher-level system control (PROFIBUS FMS or IEC 61850)
- Via the external time synchronization interface on the rear of the unit (various protocols such as IRIG B and DCF77 are possible)
- Via external minute impulse, assigned to a binary input
- From another bay control unit by means of inter-relay communication
- Via the internal unit clock.

Fig. 13/19 illustrates the settings that are possible on the DIGSI interface.

DIGSI 4 Configuration tool

The PC program DIGSI 4 is used for the convenient configuration of all SIPROTEC 4 units. Data exchange with the configuration tool plusTOOLS of the energy automation system SICAM is possible, such that the bay level information needs only be entered once. Thus errors that could arise as a result of duplicated entries are excluded.

DIGSI 4 offers the user a modern and intuitive Windows interface, with which the units can be set and also read out.

DIGSI 4 configuration matrix

The DIGSI 4 configuration matrix allows the user to see the overall view of the unit configuration at a glance (see Part 3, Fig. 3/2). For example, all allocations of the binary inputs, the output relays and the LEDs are shown at a glance. And with one click of the button, connections can be switched. Also the measuring and metering values are contained in this matrix.

Commissioning

Special attention has been paid to commissioning. All binary inputs and outputs can be read and set directly. This can simplify the wire checking process significantly for the user.

CFC: Reduced time and planning for programming logic

With the help of the CFC (Continuous Function Chart), you can configure interlocks and switching sequences simply by drawing the logic sequences; no special knowledge of software is required. Logical elements, such as AND, OR and time elements, measured limit values, etc. are available.

Display editor

A convenient display editor is available to design the display on SIPROTEC 4 units (see Part 3, Fig. 3/6). The predefined symbol sets can be expanded to suit the user. Drawing a single-line diagram is extremely simple. Operational measured values (analog values) in the unit can be placed where required.

In order to also display the comprehensive plant of the high-voltage switchgear and controlgear, the feeder control display of the 6MD66 bay control unit can have a number of pages.

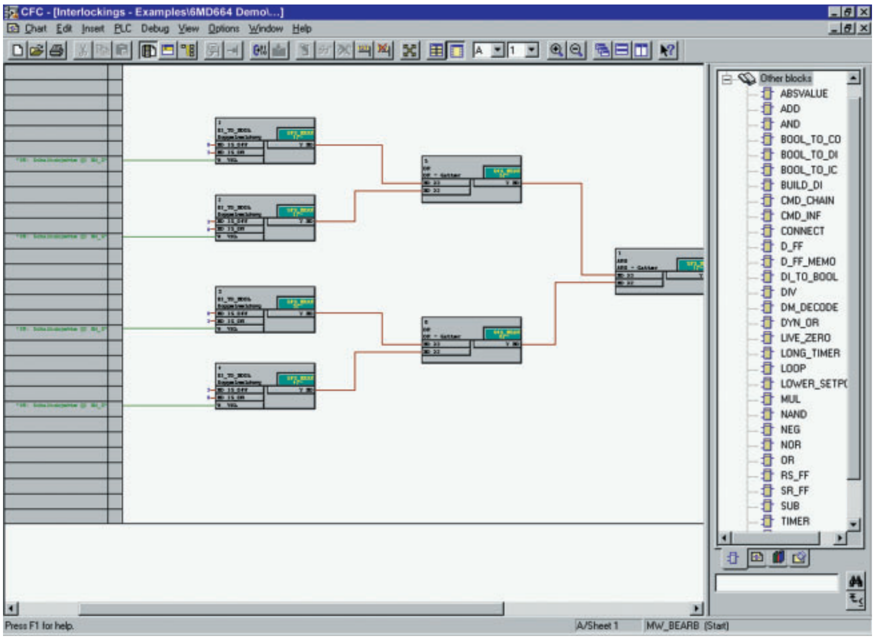


Fig. 13/20
CFC plan for interlocking logic (example)

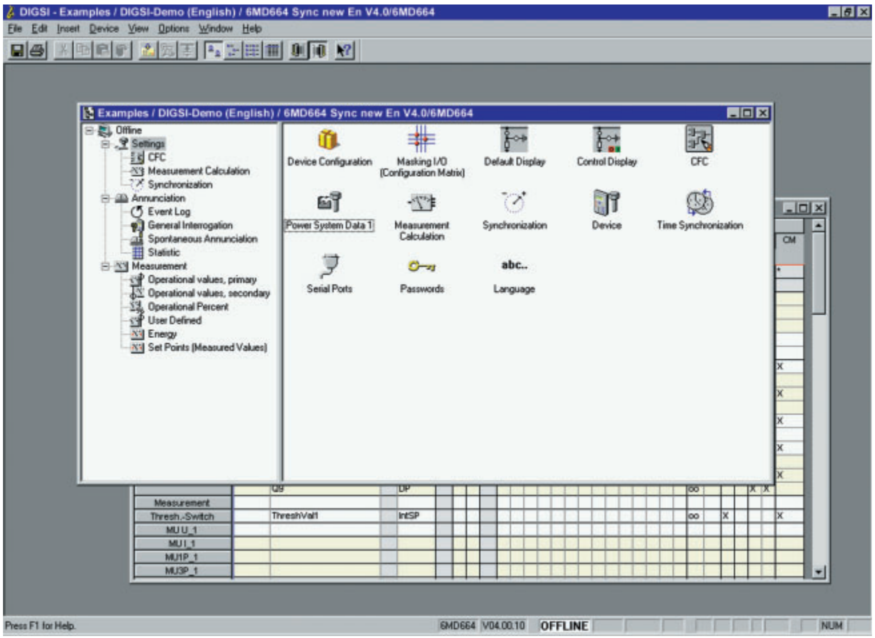


Fig. 13/21
General configuration view of the bay control unit

In this process, several pages of a control display can be configured under one another, and the user can switch between them using the cursor. The number of pages, including the basic display and the feeder control display, should not exceed 10, as otherwise the memory in the unit will be completely occupied.

Fig. 13/21 illustrates the general view of the 6MD66 bay control unit on the DIGSI 4 configuration interface.

As is the case with the SIPROTEC 4 protection units, there is an icon called "Functional Scope". It enables the configuration of measured value processing and the synchronization function.

Technical data

General unit data	
Analog inputs	
Rated frequency	50 or 60 Hz (adjustable, depending on the order number)
Rated current I_N	1 or 5 A (can be changed via plug-in jumper)
Rated voltage V_N	100 V, 110 V, 125 V, 100 V/$\sqrt{3}$, 110 V/$\sqrt{3}$ can be adjusted using parameters
Power consumption at I_N = 1A at I_N = 5A Voltage inputs	 < 0.1 VA < 0.5 VA < 0.3 VA with 100 V
Measurement range current I	Up to 1.2 times the rated current
Thermal loading capacity	12 A continuous, 15 A for 10 s, 200 A for 1 s
Measurement range voltage V	Up to 170 V (rms value)
Max. permitted voltage	170 V (rms value) continuous
Transducer inputs Measurement range Max. permitted continuous current	 ± 24 mA DC ± 250 mA DC
Input resistance, recorded power loss at 24 mA	10 Ω ± 1 % 5.76 mW
Power supply	
Rated auxiliary voltages	24 to 48 V DC, 60 to 125 V DC, 110 to 250 V DC
Permitted tolerance	-20 % to +20 %
Permitted ripple of the rated auxiliary voltage	15 %
Power consumption Max. at 60 to 250 V DC Max. at 24 to 48 V DC Typical at 60 to 250 V DC Typical at 24 to 48 V DC (typical = 5 relays picked up + live contact active + LCD display illuminated + 2 interface cards plugged in)	 20 W 21.5 W 17.5 W 18.5 W
Bridging time at 24 and 60 V DC at 48 and ≥ 110 V DC	 ≥ 20 ms ≥ 50 ms
Binary inputs	
Number 6MD663 6MD664	 50 65
Rated voltage range	24 to 250 V DC (selectable)
Pick-up value (range can be set using jumpers for every binary input)	17, 73 or 154 V DC
Function (allocation)	Can be assigned freely
Minimum voltage threshold (presetting) for rated voltage 24, 48, 60 V for rated voltage 110 V for rated voltage 220, 250 V	 17 V DC 73 V DC 154 V DC
Maximum permitted voltage	300 V DC

Binary inputs (cont'd)	
Current consumption, excited for 3 ms	approx. 1.5 mA approx. 50 mA to increase pickup time
Permitted capacitive coupling of the indication inputs	220 nF
Minimum impulse duration for message	4.3 ms
Output relay	
Live contact	1 NC/NO (can be set via jumper: Factory setting is "Break contact", i.e. the contact is normally open but then closes in the event of an error)
Number of command relays, single pole 6MD663	 35, grouping in 3 groups of 4, 1 group of 3, 9 groups of 2 and two ungrouped relays
6MD664	45, grouping 4 groups of 4, 1 group of 3, 12 groups of 2 plus two ungrouped relays
Switching capacity, command relay Make Break Break (at L/R ≤ 50 ms) Max. switching voltage Max. contact continuous current Max. (short-duration) current for 4 s	 max. 1000 W/ VA max. 30 VA 25 VA 250 V 5 A 15 A
Switching capacity, live contact ON and OFF Max. switching voltage Max. contact continuous current	 20 W/VA 250 V 1 A
Max. make-time	8 ms
Max. chatter time	2.5 ms
Max. break time	2 ms
LED	
Number RUN (green) ERROR (red) Display (red), function can be allocated	 1 1 14
Unit design	
Housing 7XP20	For dimensions drawings, see part 16
Type of protection acc. to EN60529 in the surface-mounting housing in the flush-mounting housing front rear	 IP20 IP51 IP20
Weight	
Flush-mounting housing, integrated local control 6MD663 6MD664	 approx. 10.5 kg approx. 11 kg
Surface-mounting housing, without local control, with assembly angle 6MD663 6MD664	 approx. 12.5 kg approx. 13 kg
Detached local control	approx. 2.5 kg

13

Technical data

Serial interfaces

System interfaces	
PROFIBUS FMS, Hardware version depending on Order No.:	
PROFIBUS fiber optic cable	ST connector
Baud rate	max 1.5 Mbaud
Optical wave length	820 nm
Permissible path attenuation	max. 8 dB for glassfiber 62.5/125 µm
Distance, bridgeable	max. 1.5 km
PROFIBUS RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 Mbaud
PROFIBUS RS232	9-pin SUB-D connector
Baud rate	4800 to 115200 baud
Distance, bridgeable	max. 15 m
Time synchronization DCF77/IRIG B signal	
Connection	9-pin SUB-D connector
Input voltage level	either 5 V, 12 V or 24 V
Connection allocation Pin 1	24 V input for minute impulse
Pin 2	5 V input for minute impulse
Pin 3	Return conductor for minute impulse
Pin 4	Return conductor for time message
Pin 7	5 V input for minute impulse
Pin 8	24 V input for time message
Pin 5, 9	Screen
Pin 6	Not allocated
Message type (IRIG B, DCF, etc.)	Can be adjusted using parameters
Control interface for RS232 DIGSI 4	
Connection	Front side, non-isolated, 9-pin SUB-D connector
DIGSI 4 interface (rear of unit)	
Fiber optic	ST connector
Baud rate	max. 1.5 Mbaud
Optical wave length	820 nm
Permissible path attenuation	max. 8 dB for glass fiber of 62.5/ 125 µm
Distance, bridgeable	max. 1.5 km
RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 MBaud
RS232	9-pin SUB-D connector
Baud rate	4800 to 115200 Baud
Distance, bridgeable	max. 15m
Interface for inter-unit communication	
RS485	9-pin SUB-D connector
Baud rate	max. 12 Mbaud
Distance, bridgeable	max. 1000 m at 93.75 kBaud max. 100 m at 12 Mbaud

Electrical tests

Specifications	
Standards	IEC 60255 (product standards) ANSI/IEEE C37.90.0/.1/.2 UL 508 DIN 57435 Part 303 For further standards see specific tests
Insulation tests	
Standards	IEC 60255-5 and IEC 60870-2-1
Voltage test (100 % test) All circuits except for auxiliary supply, binary inputs, communication and time synchronization interfaces	2.5 kV (rms), 50 Hz
Voltage test (100 % test) Auxiliary voltage and binary inputs	3.5 kV DC
Voltage test (100 % test) only isolated communication and time synchronization interfaces	500 V (rms value), 50 Hz
Surge voltage test (type test) All circuits except for communication and time synchronization interfaces, class III	5 kV (peak); 1.2/50 µs; 0.5 J; 3 positive and 3 negative surges at intervals of 5 s
EMC tests for noise immunity; *type test*	
Standards	IEC 60255-6, IEC 60255-22 (product standards) EN 50082-2 (generic standard) DIN 57 435 Part 303
High frequency test IEC 60255-22-1, class III and DIN 57435 part 303, class III	2.5 kV (peak value), 1 MHz; τ = 15 ms 400 pulses per s; duration 2 s
Discharge of static electricity IEC 60255-22-2 class IV EN 61000-4-2, class IV	8 kV contact discharge; 15 kV air discharge; both polarities; 150 pF; R_i = 330 Ω
Exposure to RF field, non-modulated IEC 60255-22-3 (report), class III	10 V/m; 27 to 500 MHz
Exposure to RF field, amplitude-modulated IEC 61000-4-3, class III	10 V/m; 80 to 1000 MHz; 80 % AM; 1 kHz
Exposure to RF field, pulse-modulated IEC 61000-4-3/ ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle 50 %
Fast transient interference bursts IEC 60255-22-4, IEC 61000-4-4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition frequency 300 ms; both polarities; R_i = 50 Ω; test duration 1 min
High-energy surge voltages (SURGE), IEC 61000-4-5 installation class III	Impulse: 1.2/50 µs
Auxiliary supply	common mode: 2 kV; 12 Ω, 9 µF differential mode:1 kV; 2 Ω, 18 µF
Measurement inputs, binary inputs and relay outputs	common mode: 2 kV; 42 Ω, 0.5 µF differential mode: 1 kV; 42 Ω, 0.5 µF
Conducted RF, amplitude-modulated IEC 61000-4-6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Magnetic field with power frequency IEC 61000-4-8, class IV; IEC 60255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz

13

Technical data

EMC tests for noise immunity; type test (cont'd)	
Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak); 1 to 1.5 MHz damped wave; 50 surges per second; duration 2 s; R_i = 150 to 200 Ω
Fast transient surge withstand capability ANSI/IEEE C37.90.1	4 to 5 kV; 10/150 ns; 50 impulses per second; both polarities; duration 2 s ; R_i = 80 Ω
Radiated electromagnetic interference ANSI/IEEE C37.90.2	35 V/m; 25 to 1000 MHz
Damped oscillations IEC 60894, IEC 61000-4-12	2.5 kV (peak value), 100 kHz polarity alternating, 1 MHz, 10 and 50 MHz, R_i = 200 Ω
EMC tests for interference emission; type tests	
Standard	EN 50081-1 (Basic specification)
Radio interference voltage on lines only auxiliary supply IEC-CISPR 22	150 kHz to 30 MHz class B
Interference field strength IEC-CISPR 22	30 to 1000 MHz class B

Mechanical dynamic tests	
Vibration, shock stress and seismic vibration	
During operation	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 10 to 60 Hz: ±0.075 mm amplitude; 60 to 150 Hz: 1 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 5 *g*, duration 11 ms, 3 shocks each in both directions of the 3 axes
Vibration during earthquake IEC 60255-21-2, class 1 IEC 60068-3-3	Sinusoidal 1 to 8 Hz: ± 4 mm amplitude (horizontal axis) 1 to 8 Hz: ± 2 mm amplitude (vertical axis) 8 to 35 Hz: 1 *g* acceleration (horizontal axis) 8 to 35 Hz: 0,5 *g* acceleration (vertical axis) Frequency sweep 1 octave/min 1 cycle in 3 orthogonal axes
During transport	
Standards	IEC 60255-21 and IEC 60068-2
Vibration IEC 60255-21-1, class 2 IEC 60068-2-6	Sinusoidal 5 to 8 Hz: ±7.5 mm amplitude; 8 to 150 Hz: 2 *g* acceleration Frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60255-21-2, class 1 IEC 60068-2-27	Half-sinusoidal Acceleration 15 *g*, duration 11 ms, 3 shocks each in both directions 3 axes
Continuous shock IEC 60255-21-2, class 1 IEC 60068-2-29	Half-sinusoidal Acceleration 10 *g*, duration 16 ms, 1000 shocks in both directions of the 3 axes

Climatic stress tests		
Temperatures		
Standards	IEC 60255-6	
Recommended temperature during operation	–5 to +55 °C	25 to 131 °F
Temporary permissible temperature limit during operation (The legibility of the display may be impaired above 55 °C/131 °F)	–20 to +70 °C	-4 to 158 °F
Limit temperature during storage	–25 to +55 °C	-13 to 131 °F
Limit temperature during transport Storage and transport with standard factory packaging	–25 to +70 °C	-13 to 158 °F
Humidity		
Permissible humidity stress We recommend arranging the units in such a way that they are not exposed to direct sunlight or pronounced temperature changes that could cause condensation	Annual average ≤ 75 % relative humidity; on 56 days a year up to 93 % relative humidity; condensation during operation is not permitted	

CE conformity

The product meets the stipulations of the guideline of the council of the European Communities for harmonization of the legal requirements of the member states on electro-magnetic compatibility (EMC directive 89/336/EEC) and product use within certain voltage limits (low-voltage directive 73/23/EEC).
The product conforms with the international standard of the IEC 60255 series and the German national standard DIN VDE 57 435,Part 303. The unit has been developed and manufactured for use in industrial areas in accordance with the EMC standard.

Further applicable standards:
ANSI/IEEE C37.90.0 and C37.90.1

This conformity is the result of a test that was performed by Siemens AG in accordance with Article 10 of the directive in conformance with generic standards EN 50081-2 and EN 50082-2 for the EMC directive and EN 60255-6 for the low-voltage directive.

Selection and ordering data

Description	Order No.	Order code
6MD66 high-voltage bay control unit	6MD662□ – □□□□□ – 0□□□ □□□	
Processor module with power supply, input/output modules with a total of:		
Number of inputs and outputs		
35 single-point indications, 22 1-pole single commands, 3 single commands to common potential, 1 live contact, 3 x current 4 x voltage via direct CT inputs, 2 measuring transducer inputs		
Current transformer I_N		
1 A[1)]	1	
5 A[1)]	5	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V[2)]	2	
60 V DC, threshold binary input 19 V[2)]	3	
110 V DC, threshold binary input 88 V[2)]	4	
220 to 250 V DC, threshold binary input 176 V[2)]	5	
Unit design		
For panel flush mounting, with integr. local operation, graphic display, keyboard, plug-in terminals (2/3-pin AMP connector)	D	
For panel flush mounting, with integr. local operation, graphic display, keyboard, screw-type terminals (direct connec./ring-type cable lugs)	E	
Region-specific default settings/function and language presettings		
Region DE, 50 Hz, language: German, changeable	A	
Region World, 50/60 Hz, language: English (GB), changeable	B	
Region US, ANSI, language: English (US), changeable	C	
Region World, 50/60 Hz, language: Spanish, changeable	E	
System interface (on rear of unit, port B)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single ring, ST connector	5	
PROFIBUS-FMS Slave, optical, double ring, ST connector	6	
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector	9	L 0 S
Function interface (on rear of unit, port C and D)		
No function interface	0	
DIGSI 4, electrical RS232, port C	1	
DIGSI 4, electrical RS485, port C	2	
DIGSI 4, optical 820 nm, ST connector, port D	3	
With RS485 interface for inter-relay communication, port C and DIGSI 4	4	
With RS485 interface for inter-relay communication, port C and DIGSI 4, with optical 820 nm, ST connector, port D	5	
Measured-value processing		
Full measured-value processing and display	A	
No measured-value processing and no display	F	
Synchronization		
With synchronization	A	
Without synchronization	F	
Protection function		
Without protection functions	0	
With auto-reclosure (AR)	1	
With circuit-breaker failure protection	2	
With auto-reclosure and circuit-breaker failure protection	3	

1) Rated current can be selected by means of jumpers.

2) The binary input thresholds can be selected in two stages by means of jumpers.

13

Selection and ordering data

Description	Order No.	Order code
6MD66 high-voltage bay control unit	6MD66□□ – □□□□□ – 0□□□	□□□
Processor module with power supply, input/output modules with a total of:		
Number of inputs and outputs		
50 single-point indications, 32 1-pole single commands, 3 single commands to common potential, 1 live contact, 3 x current, 4 x voltage via direct CT inputs 2 measuring transducer inputs	3	
65 single-point indications, 42 1-pole single commands, 3 single commands to common potential, 1 live contact, 3 x current, 4 x voltage via direct CT inputs 2 measuring transducer inputs	4	
Current transformer I_N		
1 A	1	
1 A / 150 % I_N	2	
5 A	5	
5 A / 150 % I_N	6	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V[1)]	2	
60 V DC, threshold binary input 19 V[1)]	3	
110 V DC, threshold binary input 88 V[1)]	4	
220 to 250 V DC, threshold binary input 176 V[1)]	5	
Unit design		
For panel surface mounting, detached operator panel, f. mount. in l.-v. case, plug-in terminals (2/3-pin AMP connector)	A	
For panel surface mounting, w /o operator panel, f. mount. in l.-v. case, plug-in terminals (2/3-pin AMP connector)	B	
For panel surface mounting, detached operator panel, f. mount. in l.-v. case, screw-type terminals (direct connec./ring-type cable lugs)	C	
For panel flush mounting, with integr. local operation, graphic display, keyboard, plug-in terminals (2/3-pin AMP connector)	D	
For panel flush mounting, with integr. local operation, graphic display, keyboard, screw-type terminals (direct connec./ring-type cable lugs)	E	
For panel surface mounting, w /o operator unit, f. mount. in l.-v. case, screw-type terminals (direct connec./ring-type cable lugs)	F	
Region-specific default settings/function and language presettings		
Region DE, 50 Hz, language: German, changeable	A	
Region World, 50/60 Hz, language: English (GB), changeable	B	
Region US, ANSI, language: English (US), changeable	C	
Region World, 50/60 Hz, language: Spanish, changeable	E	
System interface (on rear of unit, port B)		
No system interface	0	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, optical, single ring, ST connector	5	
PROFIBUS-FMS Slave, optical, double ring, ST connector	6	
PROFIBUS-DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, optical 820 nm, double ring, ST connector	9	L 0 B
IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 0 R
IEC 61850, 100 Mbit Ethernet, optical, double, ST connector	9	L 0 S

see page 13/20

1) The binary input thresholds can be selected by means of jumpers.

13

Selection and ordering data

Description	Order No.
6MD66 high-voltage bay control unit	*6MD66□□ – □□□□□ – 0□□□*
Function interface (on rear of unit, port C and D)	
No function interface	0
DIGSI 4, electrical RS232, port C	1
DIGSI 4, electrical RS485, port C	2
DIGSI 4, optical 820 nm, ST connector, port D	3
With RS485 interface for inter-relay communication, port C and DIGSI 4	4
With RS485 interface for inter-relay communication, port C and DIGSI 4, with optical 820 nm, ST connector, port D	5
Measured-value processing	
Full measured-value processing and display	A
No measured-value processing and no display	F
Synchronization	
With synchronization	A
Without synchronization	F
Protection function	
Without protection functions	0
With auto-reclosure (AR)	1
With circuit-breaker failure protection	2
With auto-reclosure and circuit-breaker failure protection	3

13

Connection diagrams

Bay unit 6MD662

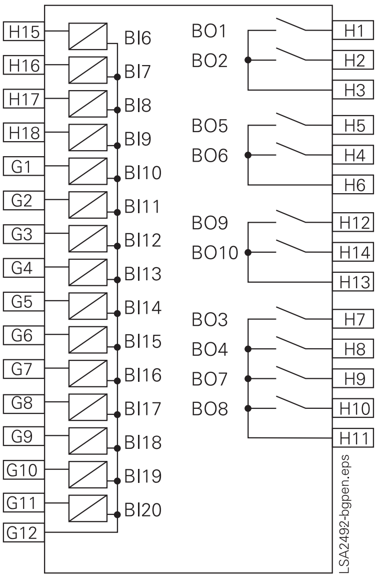


Fig. 13/22
Module 1, indications, commands

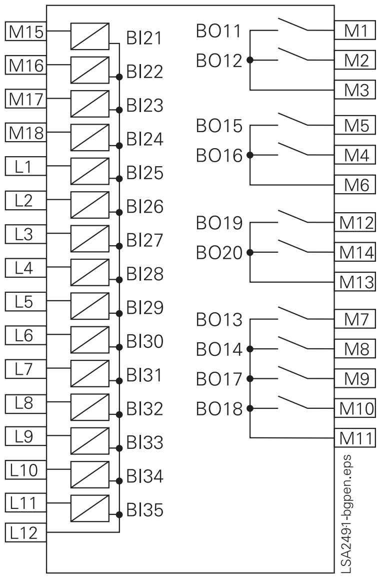


Fig. 13/23
Module 2, indications, commands

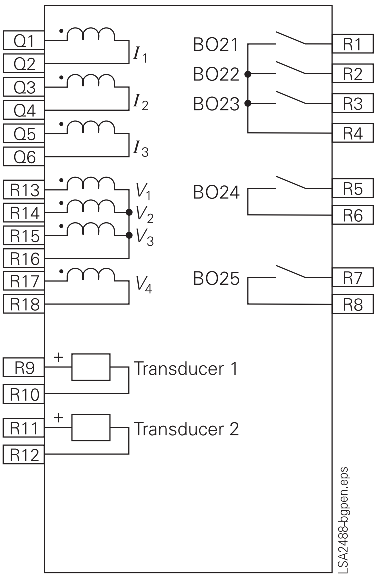


Fig. 13/24
Module 4, measuring values commands

Connection diagrams

Bay unit 6MD662

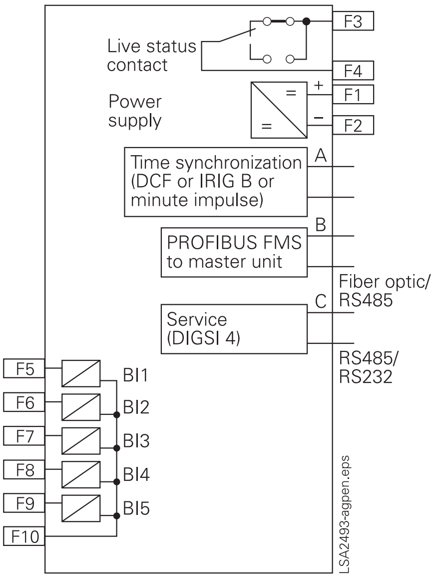


Fig. 13/25

CPU, C-CPU 2
For unit 6MD662*-****1-0AA0
and 6MD662*-****2-0AA0
(DIGSI interface, electrical, system interface
optical or electrical)

or

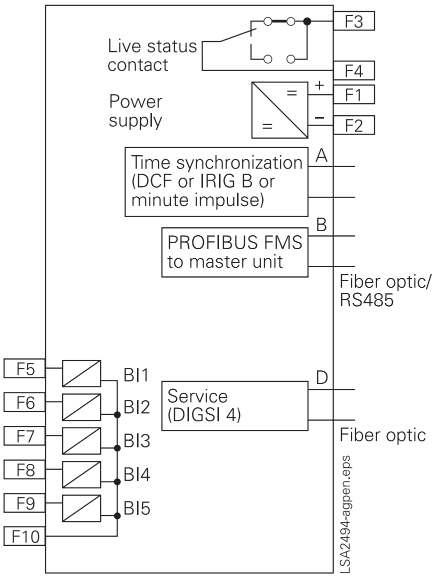


Fig. 13/26

CPU, C-CPU 2
For unit 6MD662*-****3-0AA0
(DIGSI interface, optical, system interface
optical or electrical)

or

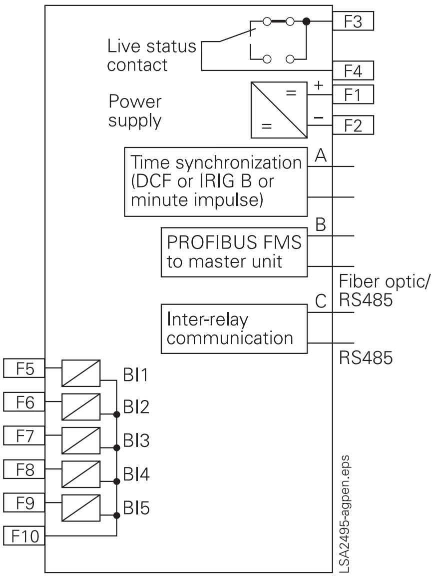


Fig. 13/27

CPU, C-CPU 2
For unit 6MD662*-****4-0AA0
(Inter-relay communication
interface electrical, system interface
optical or electrical)

or

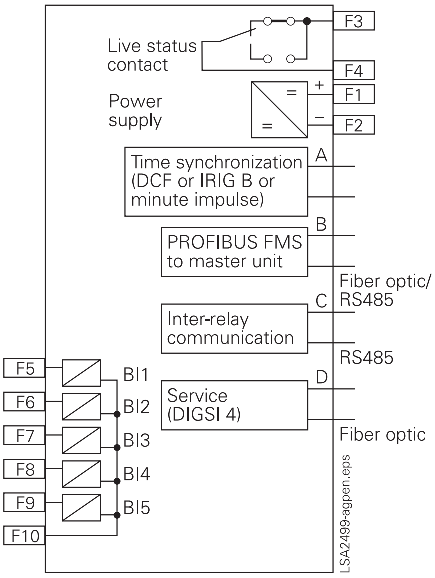


Fig. 13/28

CPU, C-CPU 2
For unit 6MD662*-****5-0AA0
(DIGSI interface, optical,
Inter-relay communication
interface electrical, system interface
optical or electrical)

Connection diagrams

Bay unit 6MD664

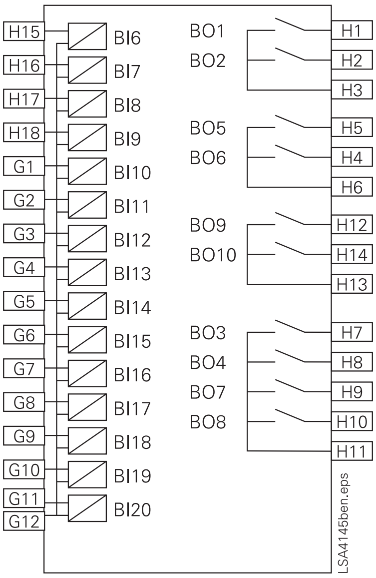


Fig. 13/29
Module 1, indications commands

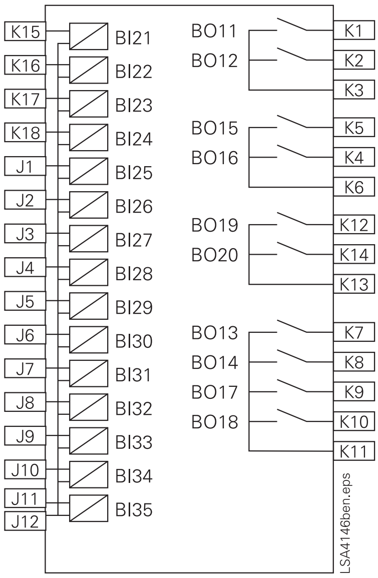


Fig. 13/30
Module 2, indications commands

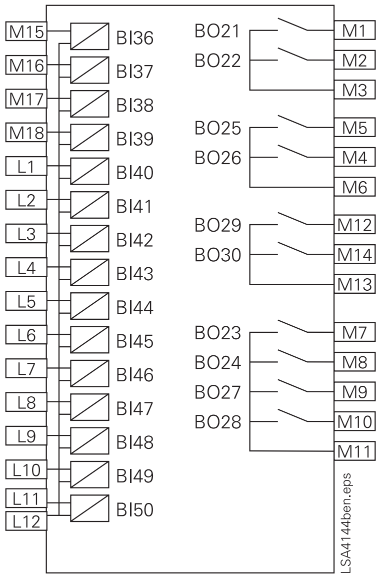


Fig. 13/31
Module 3, indications, commands

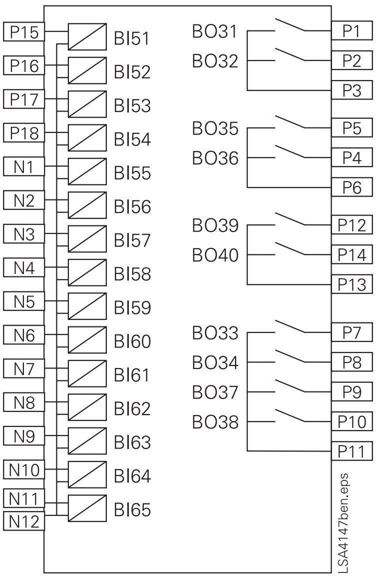


Fig. 13/32
Module 4, indications, commands

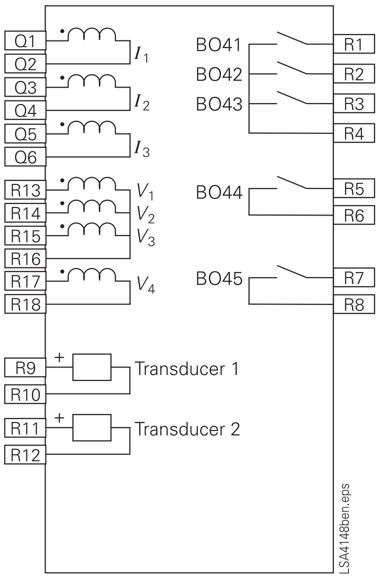
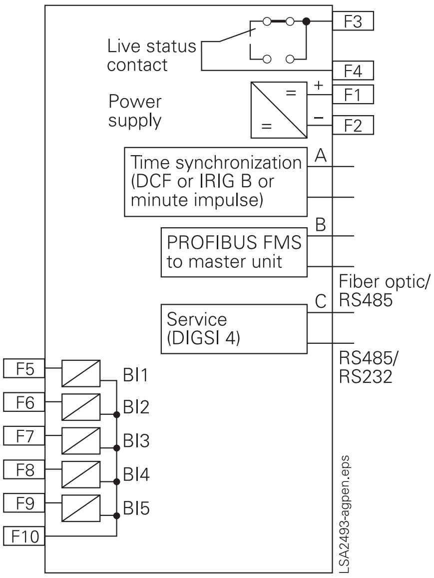


Fig. 13/33
Module 5, measuring values, commands

Connection diagrams

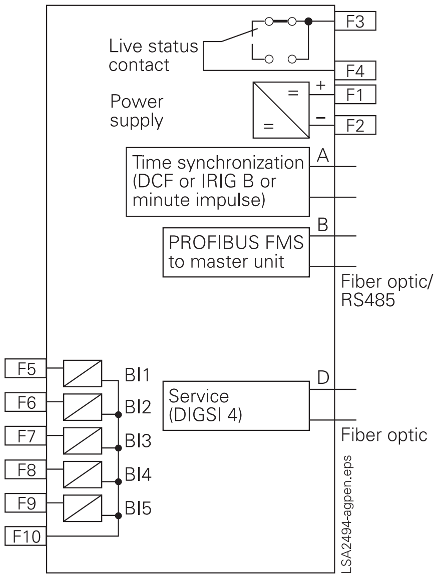
Bay unit 6MD664



or

Fig. 13/34

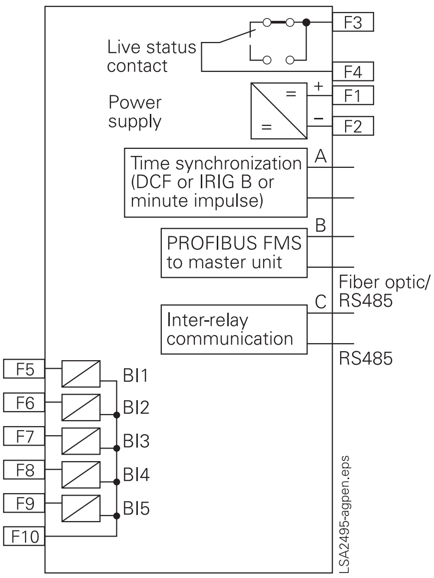
CPU, C-CPU 2
For unit 6MD664*-****1-0AA0
and 6MD664*-****2-0AA0
(DIGSI interface electric, system interface optical optical or electric)



or

Fig. 13/35

CPU, C-CPU 2
For unit 6MD664*-****3-0AA0
(DIGSI interface optical,
system interface optical
optical or electric)



or

Fig. 13/36

CPU, C-CPU 2
For unit 6MD664*-****4-0AA0
(Inter-relay communication interface electric, system interface optical or electric)

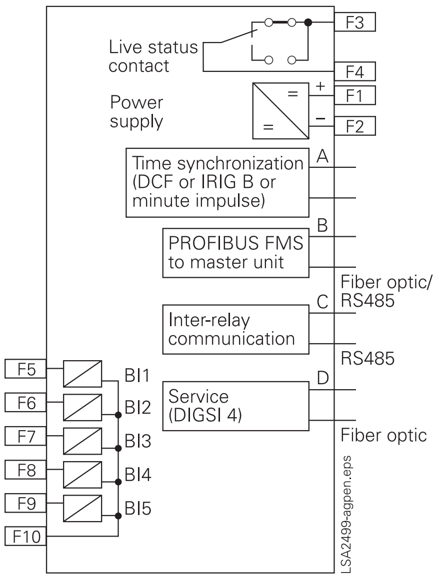


Fig. 13/37

CPU, C-CPU 2
For unit 6MD664*-****5-0AA0
(DIGSI interface optical,
(Inter-relay communication electric, system
interface optical or electric)

SIPROTEC 4 6MD665 Bay Processing Unit

LSP2314-afpen.tif

Fig. 13/38 SIPROTEC 4 6MD665 bay processing unit

Description

The 6MD665 bay processing unit stands for an innovative type of process connection via Ethernet. The connection with the intelligent SICAM HV control modules is established via the process bus connection, which is mounted directly on the switchgear.

The 6MD665 bay processing unit has the same design (look and feel) as the other protection and combined units of the SIPROTEC 4 relay series. Configuration is also performed in a standardized way with the easy-to-use DIGSI 4 configuration tool.

For operation, a large graphic display with a keyboard is available. The important operating actions are performed in a simple and intuitive way, e.g. alarm list display or switchgear control. The operator panel can be mounted separately from the unit, if required. Thus, flexibility with regard to the mounting position of the unit is ensured. Integrated key-operated switches control the switching authority and authorization for switching without interlocking.

Function overview

Application

- Process bus connection via Ethernet, optically and electrically, for control, indication, measured values, for connection to the SICAM HV modules
- Automation can be configured easily by graphic means with CFC
- Additional 8 indication inputs, 7 command relays
- Switchgear interlocking
- Inter-relay communication with other units of the 6MD66 series, even without a master station
- Interface with high-level control and protection
- Display of operational measured values I, V, P, Q, f, cos φ (power factor)
- Limit values for measured values
- Feeder diagram can have several pages
- Can be supplied in a standard housing for cubicle mounting or with a separate display for free location of the operator elements
- 4 freely assignable function keys to speed up frequently recurring operator actions
- Suitable for redundant master station
- Also available with measuring inputs and synchronization function

Communication interfaces

- System interface
  - PROFIBUS - FMS
  - IEC 60870-5-103 protocol
- Process bus
  - 10 MBd Ethernet

Selection and ordering data

Description	Order No.
6MD665 bay processing unit	*6MD665□ – □□□□□ – □AA0*
Number of inputs and outputs / measuring inputs	
8 indication inputs (5 ungrouped, 3 grouped), 7 1-pole single commands (3 grouped, 4 ungrouped), no measuring inputs	0
8 indication inputs (5 ungrouped, 3 grouped), 12 1-pole single commands (6 grouped, 6 ungrouped), 4 x voltage, 3 x current (1 A[1]) rated current) via direct CT inputs, 2 x 20 mA measuring transducer inputs with synchronization function	1
8 indication inputs (5 ungrouped, 3 grouped), 12 1-pole single commands (6 grouped, 6 ungrouped), 4 x voltage, 3 x current (5 A[1]) rated current) via direct CT inputs, 2 x 20 mA measuring transducer inputs with synchronization function	5
Rated auxiliary voltage (power supply, indication voltage)	
24 to 48 V DC, threshold binary input 19 V[2])	2
60 V DC, threshold binary input 19 V[2])	3
110 V DC, threshold binary input 88 V[2])	4
220 V to 250 V DC, threshold binary input 176 V[2])	5
Unit design	
For panel surface mounting, remote operator control unit, in low-voltage case, plug-in terminals (2/3-pin AMP connector)	A
For panel surface mounting, remote operator control unit, in low-voltage case, screw terminals (direct connection/ring- and fork-type cable lugs)	C
For panel flush mounting, with integrated local control unit (graphic display, keyboard) screw terminals (2/3-pin AMP connector)	D
For panel flush mounting, with integrated local control unit (graphic display, keyboard) screw terminals (direct connection/ring- and fork-type cable lugs)	E
For panel surface mounting, without operator control unit, in low-voltage case, screw terminals (direct connection/ring- and fork-type cable lugs)	F
Region-specific default settings/function and language presettings	
Region DE, 50 Hz, IEC, language: German, changeable	A
Region World, 50/60 Hz, language: English (GB), changeable	B
Region US (ANSI) language: English (US), changeable	C
System interface (on rear of unit, port E)	
IEC 60870-5-103 protocol, electrical RS485	2
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3
PROFIBUS-FMS Slave, electrical RS485	4
PROFIBUS-FMS Slave, optical, single ring, ST connector	5
PROFIBUS-FMS Slave, optical, double ring, ST connector	6
Function interface (on rear of unit, port C and D)	
No function interface	0
DIGSI 4, electrical RS232, port C	1
DIGSI 4, electrical RS485, port C	2
DIGSI 4, optical 820 nm, ST connector, port C	3
Inter-relay communication, electrical RS485, port C	4
Inter-relay communication, electrical RS485, port C and DIGSI 4, optical 820 nm, ST connector, port D	5
Process bus interface (on rear of unit, port B)	
One process bus interface	0

1) Rated current can be selected by means of jumpers.

2) The binary input thresholds can be selected in two stages by means of jumpers.

SIPROTEC 4 6MD61 IO-Box

Fig. 13/39 SIPROTEC 4 6MD61 IO-Box

Description

The SIPROTEC 4 IO-Box 6MD61 enables in a simple, easy way to enhance the number of binary inputs and outputs in the switchgear. It can be used directly in the bay together with other SIPROTEC4 units and also together with SICAM PAS to serve as a central process connection.

The IO-Box is based on the SIPROTEC 6MD63 and 6MD66 series, so it can be easily integrated in systems with other SIPROTEC 4 units.

The IO-Box supports a wide range of demand for additional binary inputs (BI) and binary outputs (BO), starting from 20 BI+10 BO and going up to 80 BI+53 BO. All important standard communication protocols are supported. With IEC 61850-GOOSE communication, a direct information interchange with other SIPROTEC units is possible. For simplification and cost reduction, the IO-Box is available only without automation (CFC), without keypad and without display.

Function overview

Application

- Extension of number of inputs and outputs of bay controller
- Extension of number of inputs and outputs of protection unit
- Central process connection for SICAM PAS

Features

- Standard SIPROTEC hardware for easy configuration with DIGSI
- Full EMC compliance like all other SIPROTEC devices
- Housing can be used for surface mounting or flush mounting (units are always delivered with two mounting rails for surface mounting. These rails can be dismounted for flush mounting)
- Three types with different amount of inputs and outputs available

Monitoring functions

- Operational measured values (only 6MD612)
- Energy metering values (only 6MD612)
- Time metering of operating hours
- Self supervision of relay

Communication interfaces

- IEC 61850 Ethernet
- IEC 60870-5-103 protocol
- PROFIBUS-FMS
- PROFIBUS-DP
- Service interface for DIGSI 4 (modem)
- Front interface for DIGSI4
- Time synchronization via IRIG B / DCF77

Application

The following figures show the most important applications of the SIPROTEC IO-Box 6MD61.

The configuration shown in Fig. 13/40 allows direct GOOSE communication between the SIPROTEC 4 units (6MD66, 7SJ63) and the IO-Boxes, independent of the substation controller. Of course, this configuration is also possible without substation controller. The IO-Box is used as additional digital inputs and measurements (measurements only with 6MD612), and serves as an additional command output.
The communication between IO-Box and the substation controller is established by using the IEC 61850 standard protocol.

Fig. 13/41 shows a configuration in which the IO-Box is used as a central process connection in the cubicle of the substation controller. For example, cubicle signaling lamps or a signaling horn are controlled by the command relays of the IO-Box.

Fig. 13/42 shows the communication for substations with no Ethernet protocol used. In this case, all communication lines go directly to the substation controller. If information from the IO-Box is used for switchgear interlocking, the interlocking logic must be part of the substation controller.

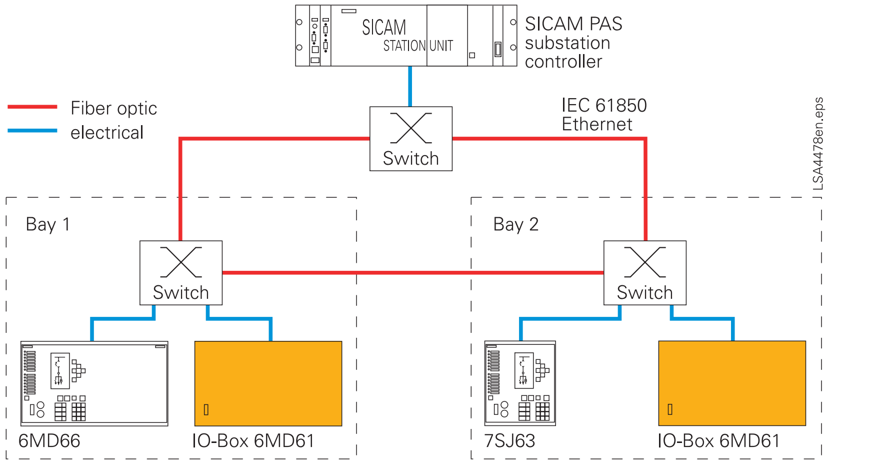


Fig. 13/40 Configuration with IO-Box in IEC 61850 substation

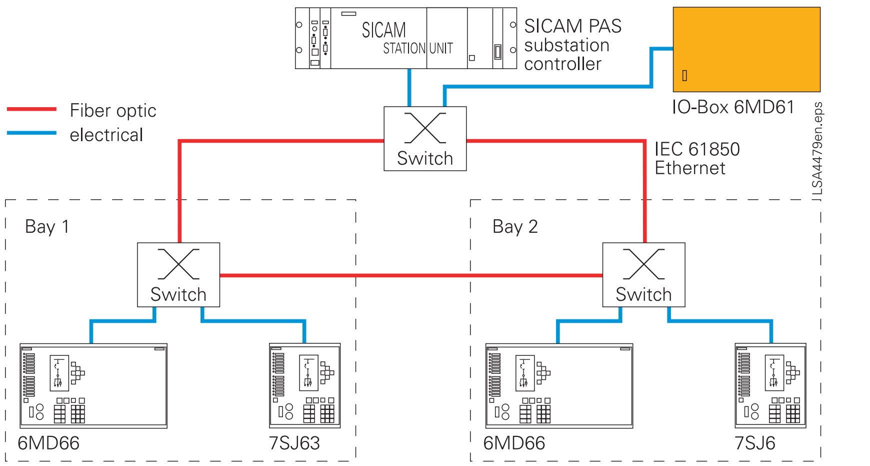


Fig. 13/41 IO-Box as central input/output for SICAM PAS substation controller

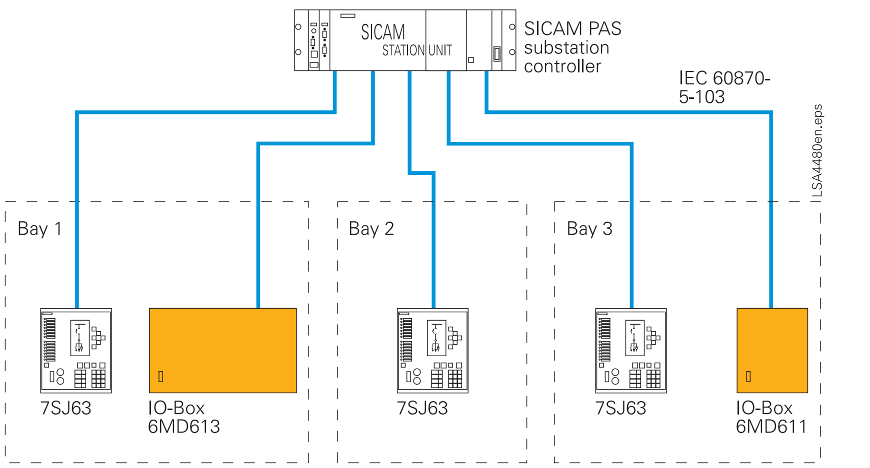


Fig. 13/42 Direct connection of IO-Boxes and protection relays to substation controller via standard protocol

Selection and ordering data

Description	Order No.	Order code
6MD61 IO-Box	*6MD61□□ – □□□□□ – 0AA0*	*□□□*
20 binary inputs, 6 command relays, 4 (2) power relays, 1 live status contact (similar to 6MD634) in 1/2 19'' housing	1	
33 binary inputs, 14 command relays, 8 (4) power relays, 1 live status contact, 2 x 20mA, 3 x V, 4 x I, (similar to 6MD636) in 1/1 19'' housing	2	
80 binary inputs, 53 command relays, 1 live status contact in 1/1 19'' housing	3	
Current transformer: rated current I_n		
no analog measuring	0	
1 A 1)	1	
5 A 1)	5	
Rated auxiliary voltage (power supply, indication voltage)		
24 to 48 V DC, threshold binary input 19 V	2	
60 V DC, threshold binary input 19 V 2)	3	
110 V DC, threshold binary input 88 V 2)	4	
220 to 250 V DC, 115 to 230 V AC, threshold binary input 176 V for input No. 8-80 for 6MD613 (C-I/O 4), otherwise threshold 88 V 2)	5	
Unit design		
Surface mounting case, without HMI, mounting in low voltage compartment, screw-type terminals (direct wiring / ring lugs), also usable as flush mounting case	F	
Region-specific default settings/function and language presettings		
Region DE, 50 Hz, language German (changeable)	A	
Region World, 50/60Hz, language English (GB) (changeable)	B	
Region USA (ANSI), 60 Hz, language English (US) (changeable)	C	
Region FR, language French (changeable)	D	
Region World, 50/60Hz, language Spanish (changeable)	E	
System interface (on rear of unit, port B)		
no system port	0	
IEC 60870-5-103 protocol, electrical RS232	1	
IEC 60870-5-103 protocol, electrical RS485	2	
IEC 60870-5-103 protocol, optical 820 nm, ST connector	3	
PROFIBUS-FMS Slave, electrical RS485	4	
PROFIBUS-FMS Slave, fiber, double ring, ST connector	6	
PROFIBUS DP Slave, electrical RS485	9	L 0 A
PROFIBUS-DP Slave, 820 nm fiber, double ring, ST connectors	9	L 0 B
IEC 61850, 100 BaseT (100 Mbit Ethernet electric, double, RJ45 connector)	9	L 0 R
IEC 61850, 100 Mbit Ethernet, fiber optic, double, ST connectors	9	L 0 S
Function interface (on rear of unit, port C)		
no function port	0	
DIGSI 4, RS232	1	
DIGSI 4, RS485	2	
DIGSI 4, 820nm fiber, ST connector	3	

1) Only for position 6 = 2

2) Thresholds can be changed (jumper) for each binary input between 19 V and 88 V, for 6MD613 BI No. 8-80 also to 176 V.

Connection diagram

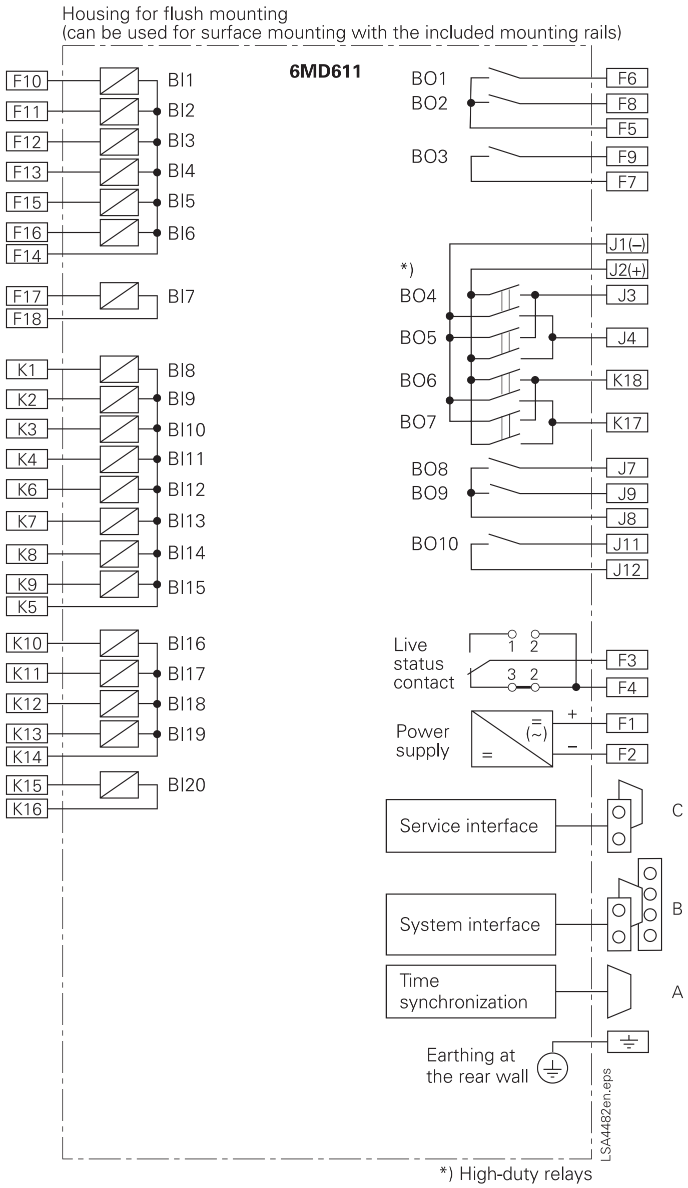


Fig. 13/43 Connection diagram

Connection diagram

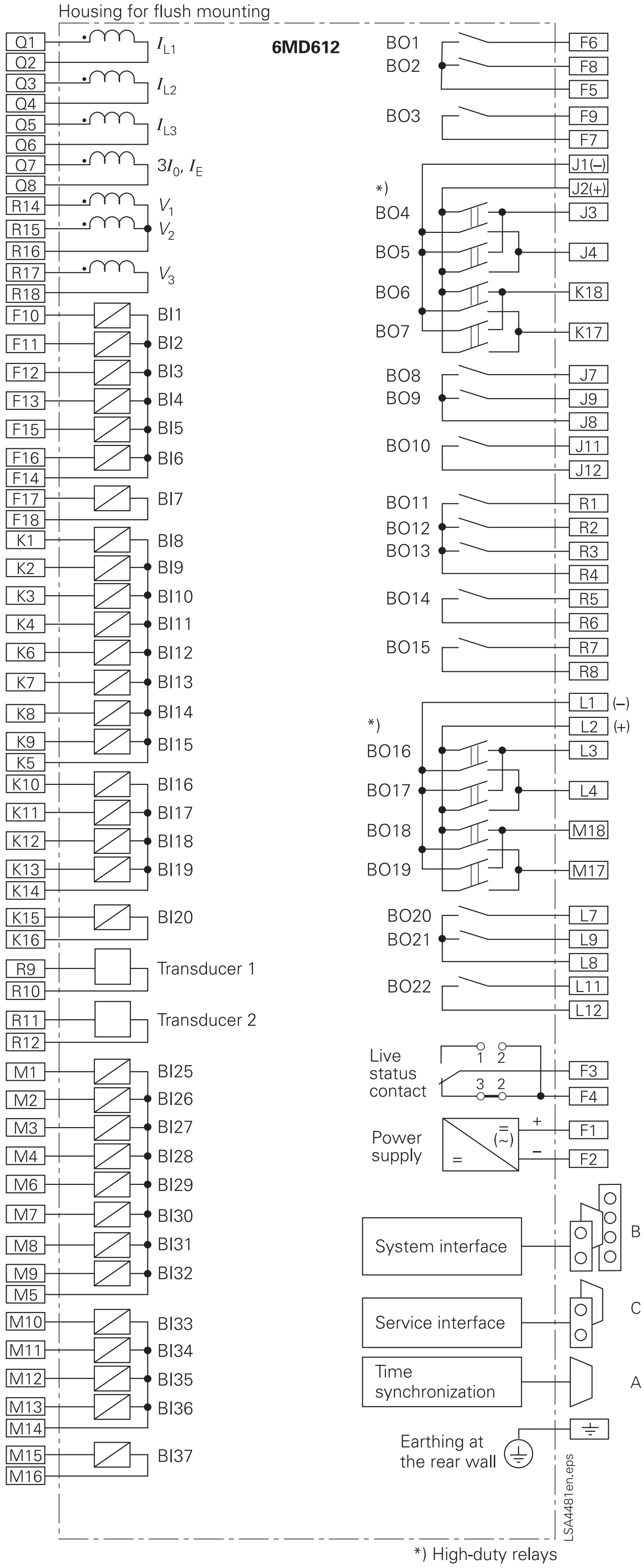


Fig. 13/44 Connection diagram

Connection diagram

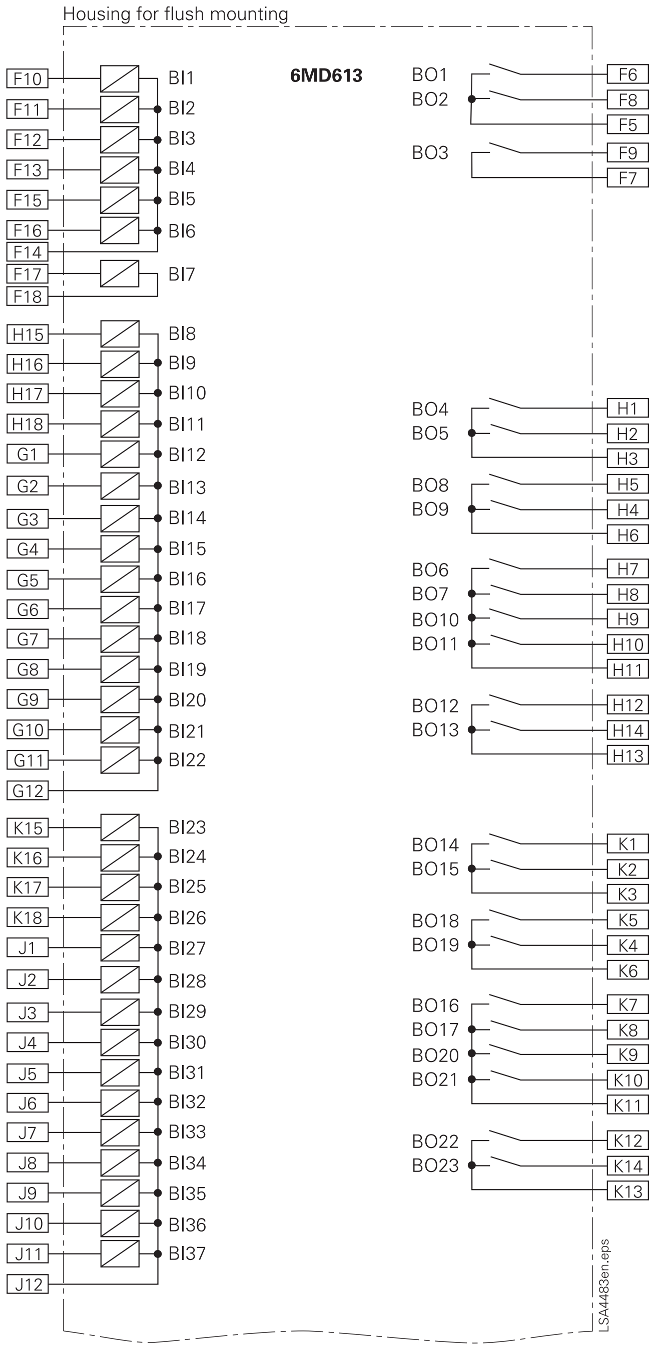


Fig. 13/45 Connection diagram, part 1;
continued on the following page

Connection diagram

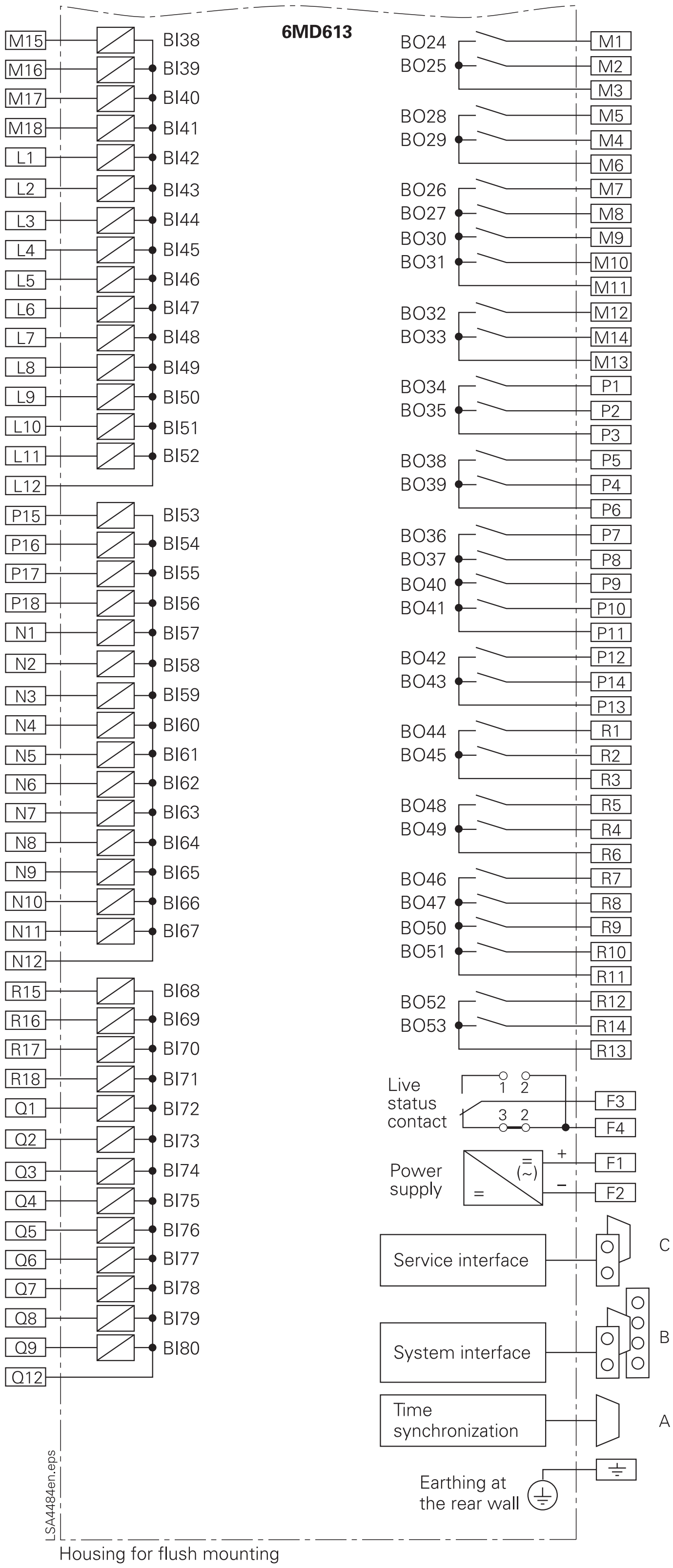


Fig. 13/45a Connection diagram part 2

13

SIMEAS P
Power Meter

SIMEAS P with transparent front cover

Fig. 13/46
SIMEAS P power meters

SIMEAS P 50

Function overview

SIMEAS P

- Power meter for panel mounting
- Measurement of voltage, current, active & reactive power, frequency, active & reactive energy, power factor, symmetry factor, voltage and current harmonics up to the 21st, total harmonic distortion
- Single-phase, three-phase balanced or unbalanced connection, four-wire connection
- PROFIBUS-DP or MODBUS RTU/ ASCII communication protocol
- Simple parameterization via RS485 communication port using SIMEAS P PAR software
- Graphic display with background illumination with up to 20 programmable screens
- Extended memory
- Battery
- Real-time clock

Selectable screen types

- 2, 3, 4 or 6 measured values in one screen
- One list screen for minimum, average and maximum values
- Two types of screens for harmonics
- One screen for oscilloscope function (sampled values or r.m.s values)
- One screen serving as phasor (vector) diagram
- Up to 20 screen types can be programmed. Switching from one screen to another can be automatic or manual

Description

SIMEAS P is a power meter for panel mounting with graphic display and background illumination. The major application area is power monitoring and recording at MV and LV level. The major information types are measured values, alarms and status information.

Measured values include r.m.s values of voltages (phase-to-phase and/or phase-to-ground), currents, active, reactive and apparent power and energy, power factor, phase angle, harmonics of currents and voltages, total harmonic distortion per phase plus frequency and symmetry factor.

The SIMEAS P comes with two binary outputs, which can be configured for energy pulses, limit violations or status signals.

The unit is also able to trigger on settable limits. This function can be programmed for sampled or r.m.s values.

SIMEAS P generates a list of minimum, average and maximum values for currents, voltages, power, energy, etc.

Independent settings for currents, voltages, active and reactive power, power factor, etc. are also possible. In case of a violation of these limits, the unit generates alarms. Up to 6 alarm groups can be defined using AND/OR for logical combinations.

The alarms can be used to increase counter values, to trigger the oscilloscope function, to generate binary output pulses, etc.

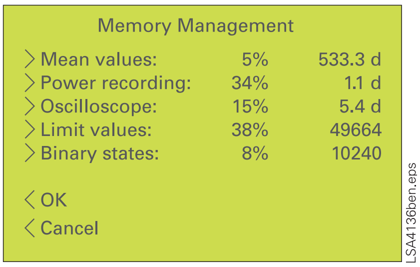
Some device variants include further features

– Real-time clock.
– 1 MB memory management: The allocation of the non-volatile measurement memory is programmable.
– Measured values and states will be recorded with time stamps.
– Recording and display of limit value violations.
– Log entries.
– Battery: Recordings like limit value violations or energy counter values stay safely in the memory up to 3 months in case of a blackout.

13

Description of SIMEAS P

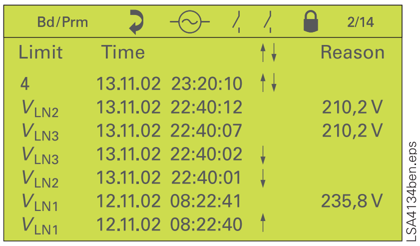
Memory management



Due to the memory capacity (1 Mbyte) and the implemented memory management, it is possible to freely configure the measurement memory for mean values, power recordings, oscilloscope, limit value violations and binary states.

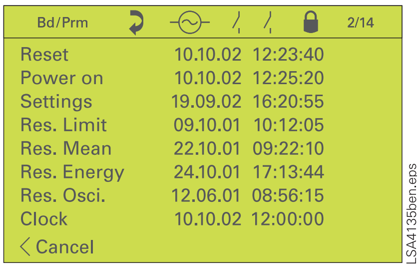
After the assignment of the percentage, the corresponding record time will be calculated and shown on the display automatically.

Recording of limit value violation



In this screen, all limit value violations will be shown in chronological order.

Screen of Log entries



The most recent change of several status information will be displayed in the "Log" screen with date and time.

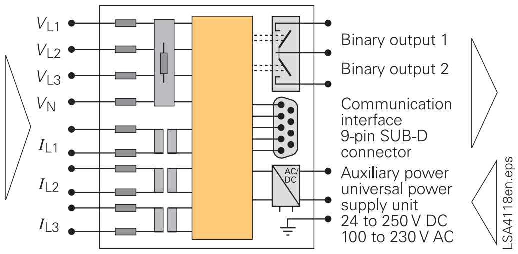


Fig. 13/47
Inputs / Outputs

Inputs / Outputs

Figure 13/47 shows the I/O pin configuration of SIMEAS P. Depending on the type of power system, the non required inputs remain unassigned.

Memory "read-out"

Recorded quantities and binary state information can be read out with the configuration software SIMEAS P PAR using the RS485 interface. Therefore a separate cable together with an RS232/RS485 converter is necessary. The configuration software offers features for indication and evaluation of all saved measured values and binary information. For further information, please refer to the chapter "SIMEAS P configuration software package" (pages 13/43 and 44).

Technology

Powerful on-board microprocessors ensure fast registration and updating of measured parameters.

SIMEAS P can be connected to any power system configuration directly (up to 690 V systems) or via transformer - from single-phase to four-wire balanced or unbalanced three-phase systems. SIMEAS P can be connected to any power system configuration up to 1 or 5 A or via current transformer.

The power supply unit allows rated supply voltages from 24 to 250 V DC and 100 to 230V AC.

Display

All parameters can be displayed on the SIMEAS P screens as required by the user. Up to 20 screens can be defined and selected with the front keys.

Number, type, content and sequence of the screens are configurable.

SIMEAS P is delivered with programmed default settings. A status line displayed in the measured value screens indicates status, interfacing and diagnostic messages of SIMEAS P.

The display is automatically refreshed every 1 s.

Communication

As communication between field devices is becoming standard, the development of the SIMEAS P communication interface is focused on the universality and flexibility of the transmission protocol. It is connected via an RS485 port with standard 9-pin SUB-D connector. SIMEAS P units are delivered with a standard PROFIBUS-DP and MODBUS RTU/ASCII protocol. The communication protocol can be selected during the setting at the device.

Operation

Clear designations as well as menu-driven configuration guarantee simple and easy operation of the SIMEAS P.

Quality

Development and production of the device is carried out in accordance with ISO 9001, ensuring highest quality standard. That means high system reliability and product service life. Further characteristics are the constant high accuracy over years, CE designation, EMC strength, as well as the compliance with all relevant national and international standards.

Measuring functions

Measured input voltages and input currents are sampled for calculation of the corresponding r.m.s. values. All parameters derived from the measured values are calculated by a processor. They can be displayed on the screens and/or transmitted via the serial interface.

With the SIMEAS P it is also possible to define several limit value groups with different limit values for the measured parameters. These can be combined with logical elements, such as AND, OR. Violations are counted and indicated on the screen or made available at the binary outputs. Triggering of the oscilloscope is possible as well.

Description of SIMEAS P

Security

Electrical isolation between inputs and outputs, assured by high-voltage testing, guarantees maximum system security.

Configuration and calibration settings are tamper-proof by password protection.

Service

SIMEAS P require no maintenance and are easy to service due to their modular design.

The units can easily be calibrated via the front keys or with PC-based configuration software.

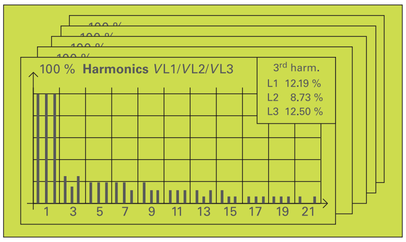
Screens

20 screens can be selected on the display of SIMEAS P with the front keys. If requested, this routine can be executed automatically.

- Number, type and sequence of the screens are freely configurable.
- 9 different types of screens can be selected:
  - 4 or 2 measured-value screens
  - 1 list screen for minimum, average and maximum values
  - 2 screens for harmonics
  - 1 screen serving as oscilloscope
  - 1 screen serving as phasor diagram

Measured-value screens

- Number and content of the measured-value screens and the parameters can be defined individually by the user.
- In addition, designations for the parameters are available for selection in the default setting: U_{L1}, U_{L2}, U_{L3}, cos φ, or V_a, V_b, V_c, PF, etc.
- To obtain a higher resolution, the lower and upper measuring value can be set in the bar chart display.
- Measured-value screens can be selected as often as required.
- Status and diagnostic messages of the device are indicated in the status line displayed on the measured-value screens.
- The screens are automatically updated every 1 s.

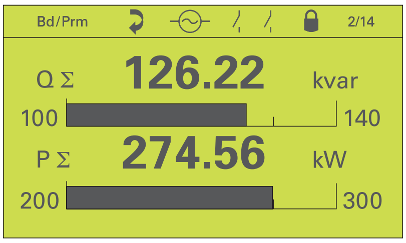


LSA4119cen.eps

Fig. 13/48
Display up to 20 screens via front buttons

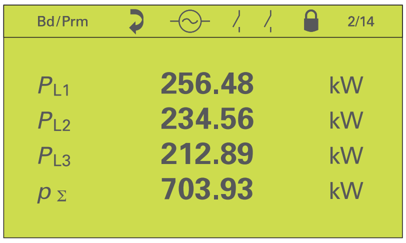
LSA4120ben.eps

Fig. 13/49
2 measured values - digital



LSA4121ben.eps

Fig. 13/50
2 measured values
digital / analog



LSA4122ben.eps

Fig. 13/51
4 measured values - digital

13

Description of SIMEAS P

Screens

Oscilloscope

- 3 parameters for voltage or current can be selected from the table of parameters (see page 13/40) and recorded with pre-fault.
- Recording is started manually or triggered automatically as soon as a limit value violation occurs.
- The cursor can be shifted with the front keys and the measured values with time indication from the cursor position and the X- and Y-axis can be read off.
- Also for recording of r.m.s. values, up to 3 parameters can be selected from the table of parameters.
- The parameter level is optimized automatically in the screens.
- The recording section displayed is indicated at the bottom of the oscilloscope screen.

Vector diagram

State and value of currents and voltages as well as their phase angles can be read off from the phase diagram screen.

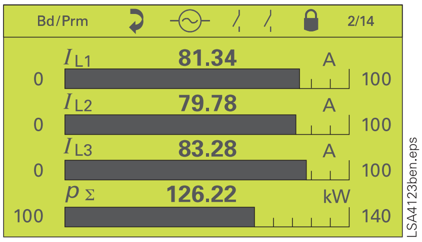


Fig. 13/52
4 measured values digital / analog

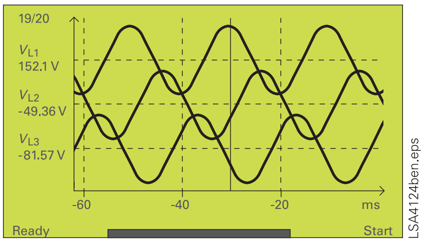


Fig. 13/53
Oscilloscope screen

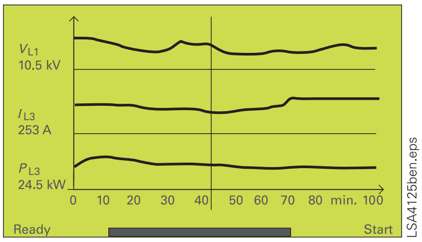


Fig. 13/54
Oscilloscope screen for r.m.s. values

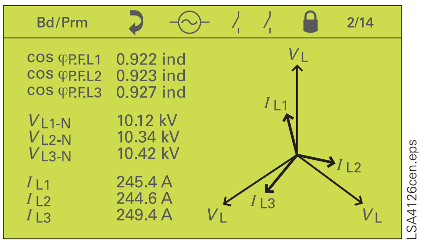


Fig. 13/55
Phasor diagram

13

Description of SIMEAS P

Screens

Harmonics

2 screens are available for the measured harmonics:

- Harmonic voltages
  Harmonic currents
- All three phases with all odd order harmonics up to the 21st harmonic are displayed on the screens.
- Each harmonic can be indicated individually in a digital display in the top right-hand corner of the screen and can be selected via the front keys.

List screens

- Minimum, average and maximum values of the parameters are indicated on the list screens from the beginning of the recording.
- Start and reset of the recording process is done via the front keys.
- The parameters are freely configurable with regard to their number and sequence.

Configuration

- Configuration of SIMEAS P is very easy.
- Rapid configuration (even without consulting the manual) is possible due to detailed index and operation via cursor and enter key.
- Configuration and calibration settings are tamper-proof by password protection.

Communication

SIMEAS P is equipped with a communication port in compliance with the EIA standard RS485 with a standard 9-pin SUB-D connector for connection to RS485 field bus systems. The SIMEAS P comes with the following standard communication protocols:

– PROFIBUS-DP V1 protocol in compliance with EN 50170 Volume 2
– MODBUS RTU/ASCII

Therefore, SIMEAS P supports all commonly used communication standards.

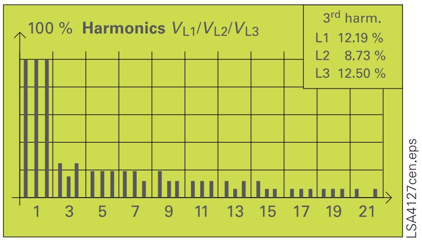


Fig. 13/56
Harmonics

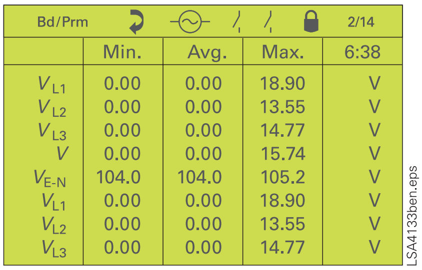


Fig. 13/57
Listing screens

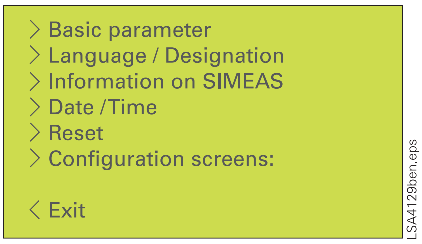


Fig. 13/58
Configuration

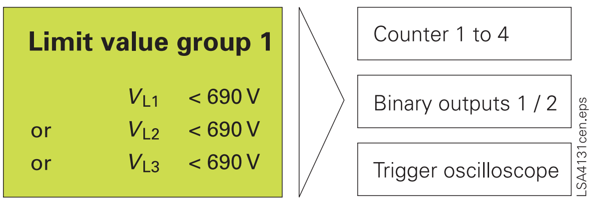


Fig. 13/59
Limit values

Profibus DP

PROFIBUS-DP and SIMEAS P are connected in a master-slave operation mode. The communication parameters are loaded to the master station using the GSD file.

The SIMEAS P supports data transmission rates from 9.6 kbit/s to 12 Mbit/s.

Optionally, the user may select different types of transmission for cyclic data transfer to the master station:

– Type 1: transmission of 3 measured values
– Type 2: transmission of 6 measured values
– Type 3: transmission of 12 measured values
– Type 4: transmission of 32 measured values

This option provides efficient and fast data communication between SIMEAS P and the master station.

The 3, 6, 12 or 32 measured values for transmission types 1 to 4 can be selected from the table of parameters (page 13/40).

Limit values

Several limit value groups with up to 6 selectable parameters can be set in the SIMEAS P.
The values can be combined with logical elements such as AND/OR; limit value violations are counted, they are available at binary outputs or used for triggering the oscilloscope.

Description of SIMEAS P

Binary outputs

The standard SIMEAS P comes with 2 binary outputs which are free for configuration with:

– Status signals
– Energy values from the table of parameters
– Limit value violations

Other configurable parameters are, for example, pulse duration, hysteresis and pulse value of the energy parameter.

Measured values and tolerances

Measured values	Measuring path[1]	Menu	Tolerances[2]
Voltage	L1-N, L2-N, L3-N, (N-E)	▼ ■ ●	± 0.1[2] % / ± 0.3 %[7]
Voltage	L1-L2, L2-L3, L3-L1, Σ[3]	▼ ■ ●	± 0.1[2] % / ± 0.3 %[7]
Current	L1, L2, L3, N, Σ[3]	▼ ■ ●	± 0.1[2] % / ± 0.3 %[7]
Active power P + import, - export	L1, L2, L3, Σ	▼ ■ ●	± 0.5 %
Reactive power Q + cap, - ind	L1, L2, L3, Σ	▼ ■ ●	± 0.5 %
Apparent power S	L1, L2, L3, Σ	▼ ■ ●	± 0.5 %
Power factor cos φ[4]	L1, L2, L3, Σ	▼ ■ ●	± 0.5 %
Active power factor cos φ[4]	L1, L2, L3, Σ	▼ ■ ●	± 0.5 %
Phase angle[4]	L1, L2, L3, Σ	▼ ■ ●	± 2 °
Frequency[5]	L1 - N	▼ ■ ●	± 10 mHz
Active power import	L1, L2, L3, Σ	▼ ■	± 0.5 %
Active power export	L1, L2, L3, Σ	▼ ■	± 0.5 %
Active power absolute	L1, L2, L3, Σ	▼ ■	± 0.5 %
Active power saldo	Σ	▼ ■	± 0.5 %
Reactive power cap	L1, L2, L3, Σ	▼ ■	± 0.5 %
Reactive power ind	L1, L2, L3, Σ	▼ ■	± 0.5 %
Reactive power absolute	L1, L2, L3, Σ	▼ ■	± 0.5 %
Apparent power	L1, L2, L3, Σ	▼ ■	± 0.5 %
Unbalance voltage	four-wire system	▼ ■ ●	± 0.5 %
Unbalance current	four-wire system	▼ ■ ●	± 0.5 %
THD voltage	L1, L2, L3	▼ ■ ●	± 0.5 %
THD current	L1, L2, L3	▼ ■ ●	± 0.5 %
Harmonic voltage V 3rd, 5th, 7th, 11th, 13th, 17th, 19th	L1, L2, L3	▼ ■ ●	± 0.5 %
Harmonic current I 3rd, 5th, 7th, 11th, 13th, 17th, 19th	L1, L2, L3	▼ ■ ●	± 0.5 %
Limit value violations	Counter 1, 2, 3, 4	▼ ■	
Analog inputs[6]	external	▼ ■	0.5 %
Binary inputs[6]	external	▼ ■	

▼ Measured values can be displayed on measured value screens (only 7KG7750, 7KG7500 and 7KG7600)

■ Measured values selectable over communication

● Measured values selectable for list screens (7KG7750) and measured values selectable for list screens and oscilloscope (only 7KG7500 and 7KG7600)

1) Phases are displayed based on the type of connection.
2) Tolerances at reference conditions are applicable from 0.5 to 1.2 times nominal value.
3) Average value of all phases.
4) Measuring beginning with 2 % of the internal apparent power.
5) Measuring beginning with 30 % of the input voltage L1-N.
6) 7KG775x, 7KG7610 and 7KG7660 only.
7) Limit values for the complete temperature range referring to: 0.1 to 1.2 x nominal range.

Description of SIMEAS P55/P100/P200

The SIMEAS P can be ordered for snap-on mounting on a 35 mm DIN rail.
For carrying out the setting of the device the configuration software is necessary.

Fig. 13/60a SIMEAS P55

Fig. 13/60b SIMEAS P100/200

Description of SIMEAS P50/P55/P610/660

Input and output modules

The SIMEAS P50/P55/P610, or the P660 respectively, can be equipped with additional analog and digital input and output modules.

The SIMEAS P50/P55 comes with 1 slot where the module may be installed.

The SIMEAS P610/P660 comes with 4 slots where the modules may be installed. For different application areas, 5 different modules are available.

Application

The input modules can be used for acquisition, display and further processing of external signals with a measurement range of 0-20 mA_{DC}.

Measured values can be shown together with their units on the display. Also the transmission of the current status of a measured signal to a central master station via PROFIBUS-DP V1 or MODBUS RTU/ASCII is possible.

In addition, mean values of all external analog channels as well as states of digital channels can be recorded and saved into the memory.
All recorded quantities and binary state information can be "read out" and evaluated with the configuration software SIMEAS P PAR.

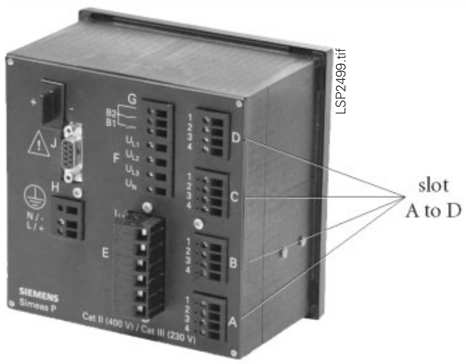


Fig. 13/61
SIMEAS P610/P660 with input and output modules

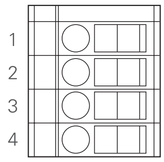
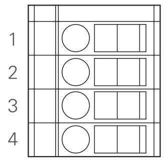
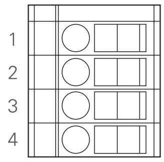
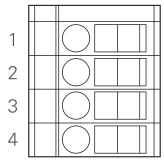
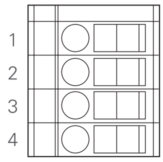
Output modules can be used for conversion of any electrical quantity (current, voltage, etc.) into a 0-20/4-20 mA_{DC} output signal, generation of impulses for metering, indication of limit value violations, as well as for switching operations.

Module assignment

The assignment of the different analog/digital modules can only be done in the course of an order of a SIMEAS P.

A change or a retrofit of modules of an existing SIMEAS P is not possible. Except for the relay module and the binary output module, the modules can be assigned to any of the 4 slots (A, B, C, D). Non-equipped slots are not used. (They may not be retrofitted either.)

Description of I/O modules

Description and applications	Terminal	Assignment
Analog input module The SIMEAS P can be equipped with a maximum of 4 analog input modules. Each module comes with 2 analog input channels, designed for a rated measurement range of 0 to 20 mA_{DC}. The modules themselves are galvanically isolated against the internal circuit and also against each other. The two channels of the module are not galvanically isolated against each other. The analog input modules can be used for: - Acquisition and display of measured signals with a measurement range of 0 to 20 mA_{DC} - Registration of limit value violations	LSA4137en.eps	AI1+ AI1- AI2+ AI2-
Binary input module The SIMEAS P can be equipped with a maximum of 4 binary input modules. Each module comes with 2 galvanically isolated and rooted binary input channels. The input voltage will be transformed into a constant current. A separate power supply for the binary input modules is not necessary. The binary input modules can be used for: - Registration of binary states/messages - Time synchronization of the SIMEAS P	LSA4138en.eps	BI1+ BIR BIR BI2+
Analog output module The SIMEAS P can be equipped with a maximum of 4 analog output modules. Each module comes with 2 channels, designed for a rated measurement range of 0 to 20 mA_{DC}. The modules themselves are galvanically isolated against the internal circuit and also against each other. The two channels of the module are not galvanically isolated against each other. The analog output modules can be used for: - Output of electrical quantities (current, voltage, power φ, cos φ, frequency, etc.) between a rated measurement range of 0 to 20 mA_{DC} or 4 to 20 mA_{DC}	LSA4137en.eps	AI1+ AI1- AI2+ AI2-
Binary output module The SIMEAS P can be equipped with a maximum of 2 binary output modules. Each module comes with 2 rooted binary output channels, realized with 2 solid-state contacts. The binary output modules can be used for: - Generation of impulses for metering - Indication of limit value violations - Indication of the device status - Indication of the rotation vector	LSA4139en.eps	BOR BO1+ BO2+ unused
Relay module The SIMEAS P can be equipped with a maximum of one relay module. The relay module comes with 3 rooted electromechanical contacts. With these contacts, higher power can be switched which is not possible when using the solid-state contacts. The relay contacts can be configured in the same manner as the channels of the binary output module. The relay contacts can be used: - As a switch at limit value violations, e.g. compensation of reactive power	LSA4140en.eps	RO1 RO2 RO3 ROR

13

Configuration software

Application

The SIMEAS P configuration software package enables a simple way to carry out the device settings. The package consists of the parameterizing software, a configuration cable with RS232/RS485 converter as well as a plug-in power supply for the converter. The SIMEAS P can be connected to any standard PC via the RS232/RS485 converter by means of a 9-pin SUB-D connector.

The software runs with Windows 2000 and XP Professional edition.

The configuration software permits a faster configuration of the SIMEAS P devices. The user can set and store parameters even without having a unit by his side. The parameters are transferred to the SIMEAS P by using the “Send to unit” command. Thus, a number of SIMEAS P units can be configured with minimum effort. The stored set of parameters is simply reloaded when a unit has to be replaced. Furthermore, firmware updates can be reloaded by means of the SIMEAS P configuration software.

The configuration package supports all SIMEAS P units and is absolutely essential for the devices SIMEAS P55/P100/P200/P6x.

Configuration of the measurement memory

Devices with measurement buffer offer the opportunity to record measured quantities and state information. Therefore, the configuration software enables menu items for the determination of values and state information which should be recorded.

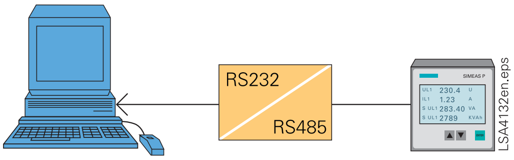


Fig. 13/62 Configuration

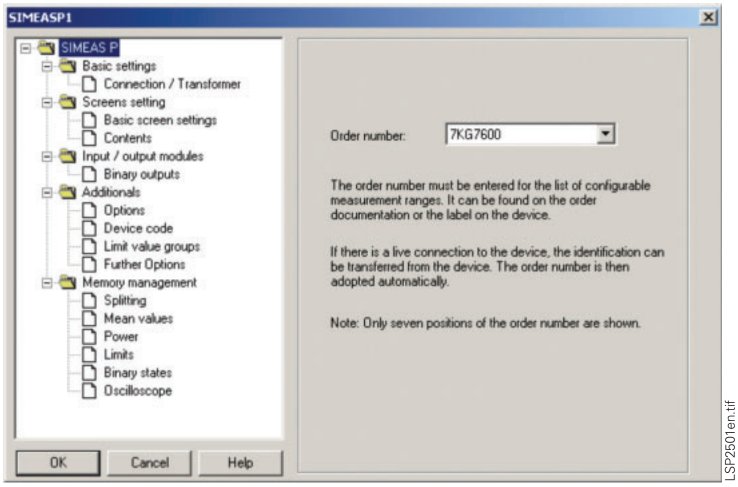


Fig. 13/63 Configuration

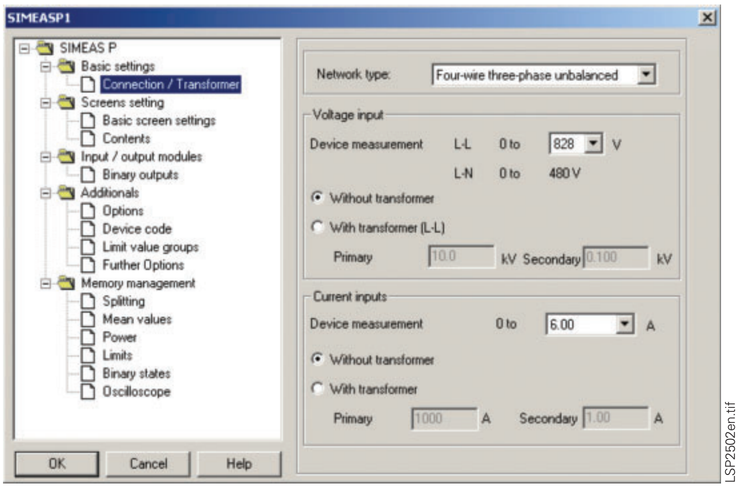


Fig. 13/64 Configuration

13

Configuration software

Memory read-out

Separate functions integrated in the configuration software, enable a read-out of the following information:

– Mean values
– Mean values of power
– Oscilloscope recordings
– State information of binary channels
– Limit value violations
– Log entries

Display and evaluation

All values and information read out via the software are shown automatically in tabular and graphical form together with the time stamp on the screen.

The context menu offers some functions (masking of signals, copy, zoom, measuring functions) for easy analysis of measured values and state information.
The following measured values can be shown in graphical form:

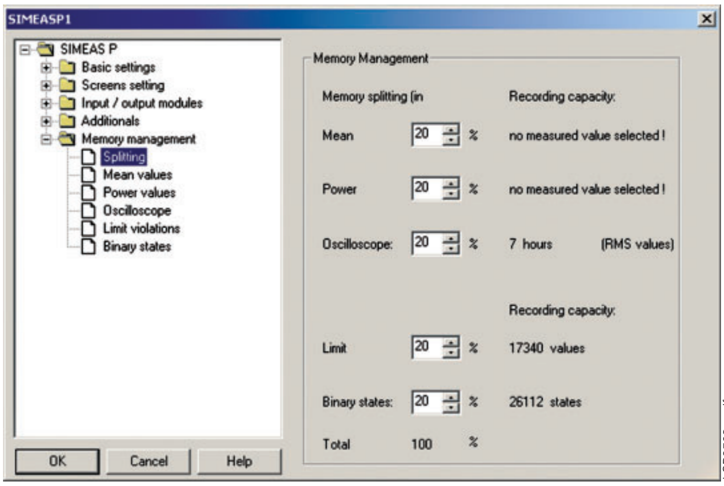
– Mean values of voltage and current
– Mean values of power
– Oscilloscope recordings
– State information of binary channels

The following information are shown in tabular form:

– Limit value violations
– Log entries

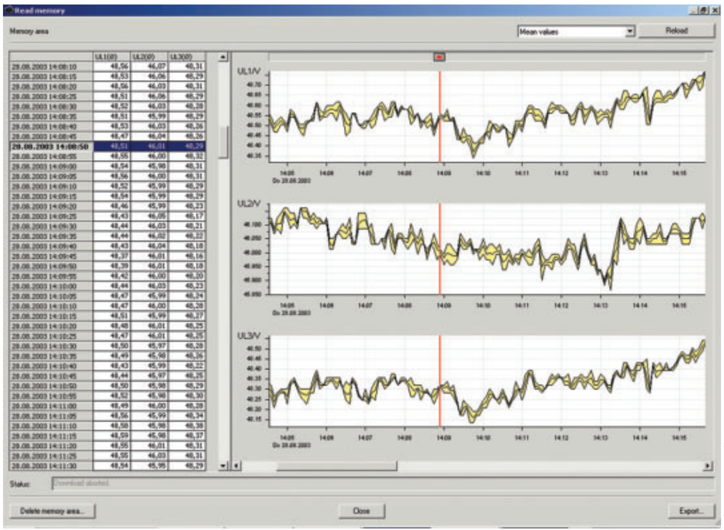
Export function

The software also enables a function for the export of transmitted values and state information into an ASCII-file. This ASCII-file can be used in other applications, e.g. MS-Excel. Oscilloscope recordings can be exported into COMTRADE formatted files.



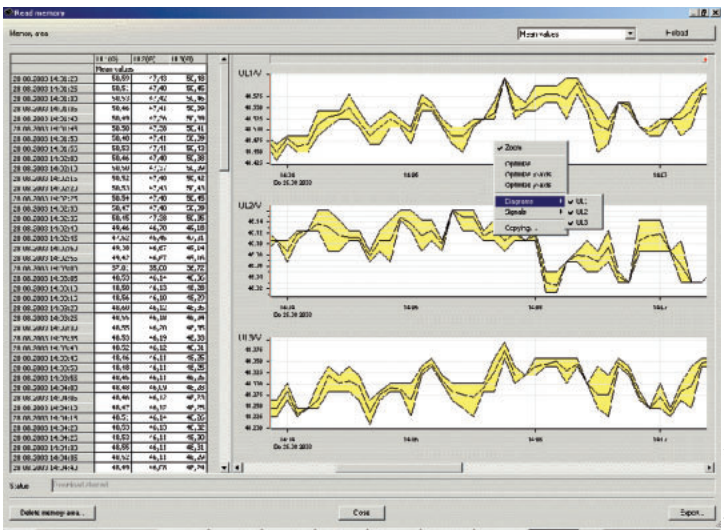
LSP2503en.tif

Fig. 13/65 Configuration of the measurement memory



LSP2504en.tif

Fig. 13/66 Display and evaluation



LSP2492en.tif

Fig. 13/67 Display and evaluation

13

Application

Application example 1

SIMEAS P as a panel-mounted device for direct electrical power monitoring.

With a very simple configuration the display of measured values is adaptable to the specific requirements of the user.

Fig. 13/68
SIMEAS P with graphic display for panel mounting

Application example 2

SIMEAS P as a panel-mounted or snap-on mounted device for use on a process bus.

Network linking is possible with the integrated RS485 port with the standard PROFIBUS-DP and MODBUS RTU/ASCII communication protocol. That allows several SIMEAS P measured parameters to be indicated, evaluated and processed at a central master station.

The major application area is the integration into PLC systems as a transducer.

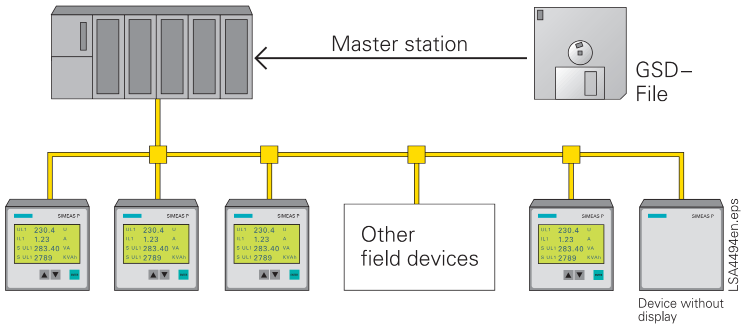


Fig. 13/68
SIMEAS P with PROFIBUS-DP

Application example 3

Fig. 13/70 shows an example of extended IO for various applications.

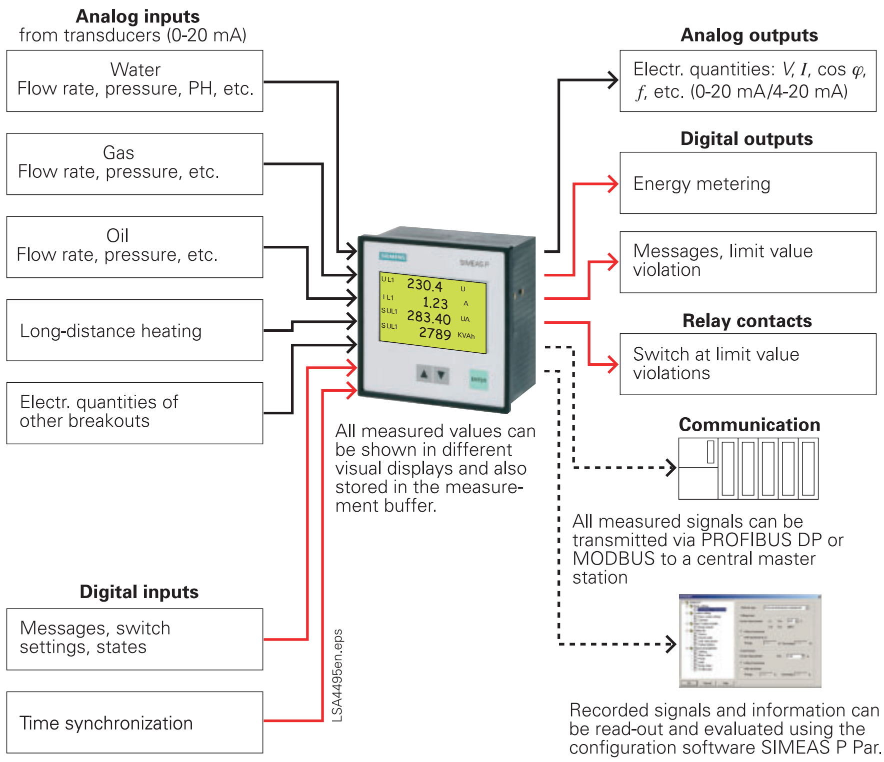


Fig. 13/70
SIMEAS P610/P660: Applications

SIMEAS P at a glance

Table 1 gives an overview of the features of the different SIMEAS P versions.

SIMEAS	P100	P500	P550	P200	P600	P650	P660	P610	P50	P55
Display		●	●		●	●	●	●	●	
Housing	96 x 144	144 x 144	144 x 144	96 x 144	144 x 144	144 x 144	144 x 144	144 x 144	96 x 96	96 x 96
for panel mounting		●	●		●	●	●	●	●	
for snap-on mounting on 35 mm DIN rail	●			●						●
Battery buffered memory 1 MB and real time clock				●	●	●	●	●	●	●
Recording limit value violations				●	●	●	●	●	●	●
Log entries				●	●	●	●	●	●	●
2 binary outputs	●	●	●	●	●	●	●	●	●	●
Number of slots for additional modules							4	4	1	1
Protocols										
RS485	●	●	●	●	●	●	●	●	●	●
MODBUS RTU/ASCII	●	●	●	●	●	●	●	●	●	●
PROFIBUS DP V1	●	●	●	●	●	●	●	●	●	●
Screens										
Oscilloscope		●	●		●	●	●	●		
Harmonics		●	●		●	●	●	●		
Degree of protection										
IP41	●	●	●	●	●	●	●	●	●	●
IP54		●	● 1)		●	● 1)	● 1)	●	● 1)	
UL Listing			●			●	●		●	●
Full parameterization via display		●	●						●	

Table 1

1) With IP54 or IP64 no UL Listing

Typical terminal assignments

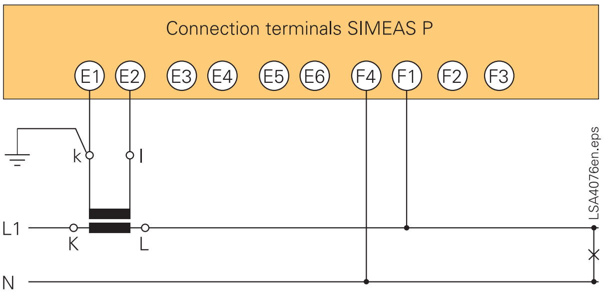


Fig. 13/69 Single-phase AC

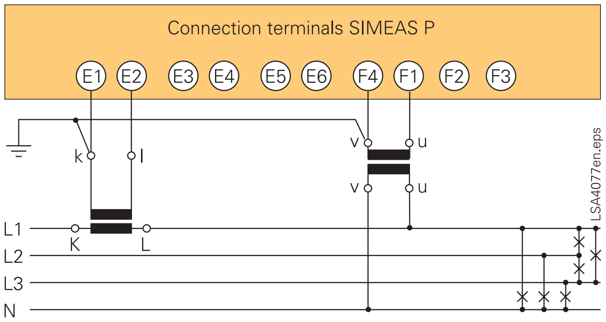


Fig. 13/70 4-wire-3-phase balanced

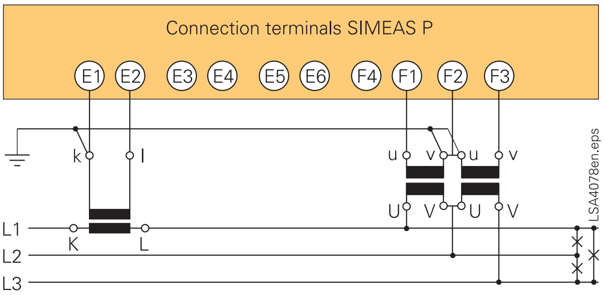


Fig.13/71 3-wire-3-phase balanced

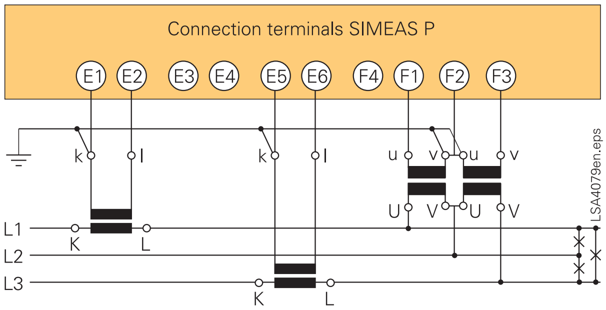


Fig. 13/72 3-wire-3-phase

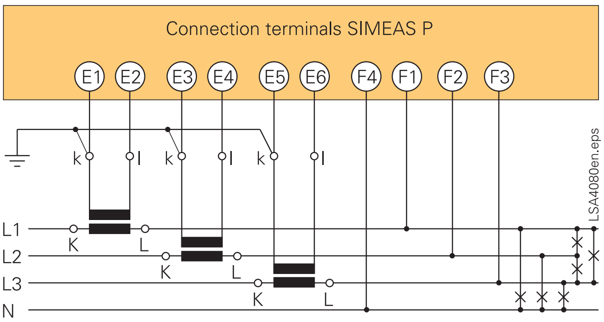


Fig. 13/73 4-wire-3-phase (low-voltage system)

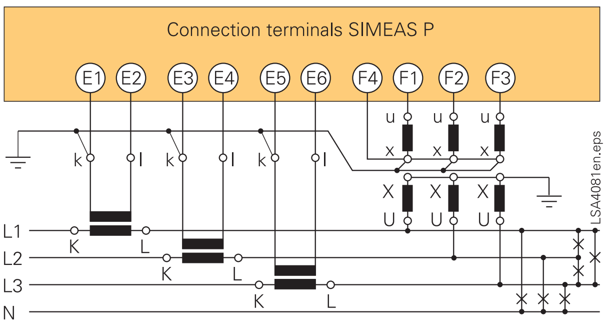


Fig. 13/74 4-wire-3-phase (high-voltage system)

The above-mentioned terminal assignments are just some configuration examples. Within the range of the permissible maximum current and voltage values, a current or voltage transformer is not compulsory.
On the other hand, Y or V-connected voltage transformers can be used.
All input or output terminals not required for measurement remain unassigned.

13

Technical data

Input	for connection to AC systems only
Max. rated system voltage Control range Rated frequency f_{EN} Input frequency range f_E Waveform	Y 400 / Δ 690 V 1.2 V_{EN} / I_{EN} 50 Hz; 60 Hz ± 5 Hz, min > 30 % V_{EN} sinusoidal or distorted up to the 21st harmonic
AC current input I_E	3 current inputs
Rated input current I_{EN} Continuous overload Surge withstand capability Power consumption	1 A; 5 A 10 A 100 A for 1 s 83 µVA at 1 A; 2.1 mVA at 5 A
AC voltage input V_E	3 voltage inputs
Rated voltage V_{EN} Continuous overload capacity Surge withstand capability Input resistance Power consumption	100/110 V; 190 V; 400 V; 690 V (phase-phase) 1.5 V_{EN} 2.0 x V_{EN} 2.663 MΩ 120 mW (V_{LE} = 400 V)
Surge voltage category	acc. to DIN EN 61010 Part 1
V_{EN} to 400 V (phase-earth) V_{EN} to 690 V (phase-phase)	III II
Auxiliary power	multi-range power supply AC / DC
Rated range Total range Power consumption 7KG7550/7KG7650/7KG775 7KG7660	24 to 250 V DC or 100 to 230 V AC ± 20 % of rated range max. 4 W or 10 VA max. 10 W or 25 VA
Binary outputs	via isolated solid-state relay
Permissible voltage Permissible current Output resistance Permissible switching frequency	230 V AC; 400 V DC 100 mA continuous 300 mA for 100 s 50 Ω 10 Hz
Measurement functions	
Sampling rate	3.6 kHz
Resolution	12 bit
Battery	
7KG72xx, 7KG76xx and 7KG77	Varta CR2032, 3 V, Li-Mn or similar
Real-time clock (7KG72xx/7KG76xx/7KG77xx)	
Deviation	150 ppm
Display (7KG75xx / 7KG76xx)	high-resolution graphic display
Resolution Dimensions Background illumination	120 x 240 pixel 103 x 60 mm yellow-green
Communication interface	
Interface Termination system Transmission rate Transmission protocols parameterizable	 9-pin SUB D connector 12 Mbit/sec max. with PROFIBUS MODBUS RTU / ASCII RS485 internal PROFIBUS-DP V1.0 MODBUS RTU / ASCII
Ambient temperature	acc. to IEC 60688
Operating temperature range Storage/transportation Temperature range Climatic Utilization category	0 °C to + 55 °C - 25 °C to + 70 °C EN 60721-3-3 rare easy dewfall IR2 (environment)
Dielectric strength	
Acc. to IEC 60688	5 kV 1.2 / 50 µs

Unit design	
Housing construction 7KG7100 and 7KG7200, 7KG7755	Housing for snap-on mounting on a 35 mm rail according to DIN EN 50022. Degree of protection IP 41 94 x 142 x 82.5 mm (W x H x D)
Housing construction 7KG7500 and 7KG7600, 7KG7750	Panel-mounting housing according to DIN 43700. Degree of protection IP 41 front (optional IP 54) SIMEAS P50: IP64 (option) 144 x 144 x 115.3 mm (W x H x D)
Connector elements Auxiliary power Voltage inputs Current inputs Binary outputs RS485 bus interface	Degree of protection IP 20 (terminals) Terminal for cable diameter 2.5 mm^2 Terminal for cable diameter 2.5 mm^2 Terminal for cable diameter 4.0 mm^2 Terminal for cable diameter 2.5 mm^2 9-pin SUB-D connector
Weight	
7KG7100 / 7KG7200 7KG7500 / 7KG7600	Approx. 0.55 kg Approx. 0.75 kg
7KG7610/7KG7660 with 4 I/O modules	 Approx. 0.95 kg
Specification of analog/digital input and output modules	
	only for 7KG7610/7KG7660/7KG775x
Analog input module	
Rated input current Output range Input impedance Power consumption at I_N 0 24 mA Accuracy	0 - 20 mA_{DC} 0 - 24 mA_{DC} 50 Ω ± 0.1 % 2 x 29 mW 0.5 % of measuring range limit
Binary input module	
Max. input voltage Max. current at high level Current consumption at high level Low level High level Time lag between low-high, high-low	300 V_{DC} 53 mA 1.8 mA ≤ 10 V ≤ 19 V max. 3 ms
Analog output module	
Rated output current Output range Max. load impedance Accuracy	0 - 20/4 - 20 mA_{DC} 0 - 24 mA_{DC} 250 Ω typ. 0.2 %; max. 1.1 % of nominal
Binary output module	
Permissible voltage Permissible current Permissible impulse current Output resistance Triggering current Triggering power	230 V_{AC}/250 V_{DC} 100 mA 300 mA for 100 ms 50 Ω 5 mA 25 mW
Permissible switching frequency	10 Hz
Relay module	
Permissible voltage Permissible current Min. current Permissible power Output resistance Max. reaction time Max. drop-out time	270 V_{AC}/120 V_{DC} 5 A 1 mA at 5 V_{DC} 5 A/250 V_{AC} or 5 A/30 V_{DC} 50 mΩ 10 ms 7 ms

Selection and ordering data

Description	Order No.
Power meter without display	
SIMEAS P100	*7KG7100-0AA00-0AA0*
Standard snap-on mounting unit (96 x 144 mm)	
SIMEAS P200	*7KG7200-0AA00-0AA0*
Extended snap-on mounting unit (96 x 144 mm) with real-time module, battery and memory for recording of measured quantities	
Power meter with graphic display	
SIMEAS P500	*7KG75□0-0AA0□-0AA0*
Standard built-in device for control panels 144 x 144 mm with graphic display	
Version	
Standard	*0*
US (with UL-listing and US-terminals)	*5*
Facia	
Degree of protection IP 41 (standard)	*1*
Degree of protection IP 54	*2*

SIMEAS P600	*7KG76□0-0□□0□-0□□0*
Extended built-in device for control panels 144 x 144 mm with graphic display, real-time module, battery and memory for recording of measured quantities	
Version	
without I/O modules	*0* *A* *A* *A* *A*
with I/O modules	*1*
US without I/O modules (with UL-Listing and US-terminals)	*5* *A* *A* *A* *A*
US with I/O modules (with UL-Listing and US-terminals)	*6*
I/O module in slot A	
Without	*A*
2 binary outputs	*B*
2 binary inputs	*C*
2 analog outputs (0-20/4-20 mA_{DC})	*D*
2 analog inputs (0-20 mA_{DC})	*E*
3 relay outputs	*G*
I/O module in slot B	
Without	*A*
2 binary outputs	*B* *)
2 binary inputs	*C*
2 analog outputs (0-20/4-20 mA_{DC})	*D*
2 analog inputs (0-20 mA_{DC})	*E*
Facia	
Degree of protection IP 41 (standard)	*1*
Degree of protection IP 54	*2*
I/O module in slot C	
Without	*A*
2 binary inputs	*C*
2 analog outputs (0-20/4-20 mA_{DC})	*D*
2 analog inputs (0-20 mA_{DC})	*E*
I/O module in slot D	
Without	*A*
2 binary inputs	*C*
2 analog outputs (0-20/4-20 mA_{DC})	*D*
2 analog inputs (0-20 mA_{DC})	*E*

*) Only if position 9 ≠ G

13

Selection and ordering data

Description	Order No.
Power meter	
SIMEAS P50/P55 with UL-Listing	*7KG775□-0□A0□-0AA0*
built-in device for control panels 96 x 96 mm with graphic display	0
Snap-on mounting device 96 x96 mm without graphic display	5
I/O module	
Without (standard)	A
2 binary outputs	B
2 binary inputs	C
2 analog outputs (0-20/4-20 mA_{DC})	D
2 analog inputs (0-20 mA_{DC})	E
3 relay outputs	G
Front protection class	
IP41 (standard)	1
IP64	2
SIMEAS P configuration package	*7KG7050-8A□*
consisting of:	
Software for configuration, calibration of SIMEAS P units by means of a personal computer	
Cable connector for connecting SIMEAS P to a PC length 5 m incl. RS232/RS485 converter	
Connector: PC-side: 9-pin SUB D connector, female	
SIMEAS P side: 9-pin SUB D connector, male	
Plug-in power supply unit for the converter	
Power supply	
230 V AC /50 Hz	A
120 V AC / 60 Hz	B
Mounting kit for built-in devices on a 35 mm rail For the devices SIMEAS P5xx-7KG75xx and SIMEAS P6xx-7KG76xx, an optional mounting kit for snap-on mounting on a 35 mm DIN rail acc. to DIN EN 50022 is available. This also enables mounting of SIMEAS P devices with a display on a 35 mm rail.	*7KG7052-8AA*

13

SIMEAS T
Digital Transducer

Fig. 13/77
SIMEAS T

Description

The SIMEAS T universal transducer allows measurement of all electrical quantities occurring in any network in a single unit. Especially in power plants and substations transducers are used for isolation of electrical signals and for further processing of measured values. Any desired measured value (current, voltage, active power, frequency, etc.) can be assigned to each of the 3 analog outputs, as well as any desired measuring range.

The output signal (e.g. -10 to 0 to 10 mA, ± 20 mA, 4 to 20 A, 0 to 10 V, etc.) can be freely parameterized for every output channel. The binary output can be used as a kWh meter to register the energy or as a limit monitor.

Input currents up to max. 10 A or input voltages up to 600 V with rated frequencies of 16 2/3, 50 or 60 Hz can be connected.

The SIMEAS T is available with an RS232 or an RS485 interface. The device with RS485 interface can be installed for operation on an IEC 60870-5-103 bus.

The unit can be reparameterized with the SIMEAS T PAR software package.

- SIMEAS T PAR - Parameterization software
  SIMEAS T digital transducers with RS232 or RS485 interface can be parameterized or calibrated with the PC software SIMEAS T PAR. The measured quantities can be displayed online on the PC via a graphical meter or can be recorded and stored over a period of up to one week. The SIMEAS T PAR software enables the self-parameterization of the digital transducer according to the desired parameter setting.
- SIMEAS EVAL - Evaluation software
  Using the SIMEAS EVAL evaluation software, the previously stored values with SIMEAS T PAR can be edited, evaluated and printed in the form of a graphic or table. SIMEAS EVAL is a typical Windows program, i.e. it is completely window-oriented and all functions can be operated with the mouse or keyboard. SIMEAS EVAL is installed together with the SIMEAS T PAR parameterization package.

Function overview

Application

- All measured values in any desired power supply system can be measured with one single unit, the SIMEAS T
- Any desired measured value (current voltage, active power, frequency, etc.) can be assigned to each of the 3 analog outputs, as well as any desired measuring range
- The output signal can be freely parameterized for every output
- The binary output can be used as a kWh meter to register the energy or as a limit monitor
- Input currents up to max. 10 A or input voltages up to 600 V with rated frequencies of 50, 60 or 16 $^2/_3$ Hz can be connected
- Three freely parameterizable analog outputs
- One binary output for work or limit signal
- For connection to any power control system
- IEC 60870-5-103 communication protocol for devices with RS485 interface

Features

- Smallest size
- CE mark
- EMC interference immunity
- Satisfies relevant international standards
- High quality, long life
- Electrical isolation with high test voltage
- High measuring accuracy
- Real r.m.s measurement
- Powerful output signal circuits
- One unit for all applications
- All data freely parameterizable
- High plant security and reliability

Communication interfaces

- RS232 or RS485 interface

Parameterization

for universal transducer with RS232/RS485 interface

Selection of measuring and metering quantities

Depending on the type of connection, the transducer generally calculates all measured or metered values marked with ●. Of these, any 3 measured variables ▼ can be connected to the 3 analog outputs and any measured parameter ■ to the limit monitor or for work metering to the binary output.

All measured values marked with ● are transmitted via the serial interface.

The following parameters can be defined with SIMEAS T PAR software (see page 13/59 for a description):

Basic parameter

Operating mode

- Direct connection without instrument transformer
- Single-phase AC
- Three-wire three-phase AC, balanced
- Three-wire three-phase AC, unbalanced
- Four-wire three-phase AC, balanced
- Four-wire three-phase AC, unbalanced

System frequency

- 50 Hz
- 60 Hz
- 16 $^2/_3$ Hz

Voltage inputs

- Without instrument transformer L - N in range 0 to 90 V
- Without instrument transformer L - N in range 0 to 180 V
- Without instrument transformer L - N in range 0 to 450 V
- With instrument transformer by indication in plain text: prim./sec. Example: 10 / 0.1 kV

Current inputs

- Without instrument transformer in range 0 to 2 A
- Without instrument transformer in range 0 to 4 A
- Without instrument transformer in range 0 to 10 A
- With instrument transformer by indication in plain text: prim./sec. Example: 100 / 1 A

Analog output 1

Measured variable

- Selecting measured variable from Table 13/2, e.g. total active power

Measuring range

- Entering primary measuring range with starting range / end range, e.g. -100 to +100 MW

Output signal

- Entering output signal with starting range / end range in range: -20 to + 20 mA or -10 to +10 V, e.g. 4 to 20 mA

Output signal limit

- Entering output signal limit with lower range / upper range e.g. lower range + 4 mA / upper range + 22 mA

Characteristic

- Characteristic, linear
- With knee-point at measuring range / at output signal, e.g. knee-point at + 50 MW and + 2 mA

Analog outputs 2 and 3 like analog output 1

Binary output

- No signal
- Unit in operation, signal upon transducer disturbance
- Limit signal
  Select the measured variable from Table 13/2.
  Specify the measurement range limit.
  Select whether a signal is issued on undershoot or overshoot, e.g. limit in the case of the measured variable “voltage”. Signal if the value is less than 9.9 kV
- Power metering
  Select the power variable from Table 13/2. Specify the power variable pulse rate, e.g. power variable: total active power reference; pulse rate 10 pulses/kWh.

13

Parameterization

Type of connection		Single-phase AC	Three-wire balanced	Three-wire unbalanced	Four-wire balanced	Four-wire unbalanced	Measuring units
Measured variables							
Voltage	$U_{L1\text{-}N}$	▼ ■ ●			▼ ■ ●	▼ ■ ●	V, kV
Voltage	$U_{L2\text{-}N}$					▼ ■ ●	V, kV
Voltage	$U_{L3\text{-}N}$					▼ ■ ●	V, kV
Voltage	$U_{L1\text{-}L2}$		▼ ■ ●	▼ ■ ●		▼ ■ ●	V, kV
Voltage	$U_{L2\text{-}L3}$		▼ ■ ●	▼ ■ ●		▼ ■ ●	V, kV
Voltage	$U_{L3\text{-}L1}$		▼ ■ ●	▼ ■ ●		▼ ■ ●	V, kV
Voltage	$U_{E\text{-}N}$					▼ ■ ●	V, kV
Current	I_{L1}	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	A, kA
Current	I_{L2}			▼ ■ ●		▼ ■ ●	A, kA
Current	I_{L3}			▼ ■ ●		▼ ■ ●	A, kA
Current	I_{L0}					▼ ■ ●	A, kA
Frequency	f_{L1}	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	Hz
Phase angle	φ	▼ ●	▼ ●	▼ ●	▼ ●	▼ ●	°
Active power	P_{total}	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	W, kW, MW
Active power	P_{L1}					▼ ■ ●	W, kW, MW
Active power	P_{L2}					▼ ■ ●	W, kW, MW
Active power	P_{L3}					▼ ■ ●	W, kW, MW
Reactive power	Q_{total}	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	var, kvar, Mvar
Reactive power	Q_{L1}					▼ ■ ●	var, kvar, Mvar
Reactive power	Q_{L2}					▼ ■ ●	var, kvar, Mvar
Reactive power	Q_{L3}					▼ ■ ●	var, kvar, Mvar
Power factor	$\cos\varphi_{total}$	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	–
Power factor	$\cos\varphi_{L1}$					▼ ■ ●	–
Power factor	$\cos\varphi_{L2}$					▼ ■ ●	–
Power factor	$\cos\varphi_{L3}$					▼ ■ ●	–
Apparent power	S_{total}	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	▼ ■ ●	VA, kVA, MVA
Power variables							
Active power, consumption	kWh_{total}	■ ●	■ ●	■ ●	■ ●	■ ●	kWh/pulse
Active power, consumption	kWh_{L1}					■ ●	kWh/pulse
Active power, consumption	kWh_{L2}					■ ●	kWh/pulse
Active power, consumption	kWh_{L3}					■ ●	kWh/pulse
Active power, delivered	kWh_{total}	■ ●	■ ●	■ ●	■ ●	■ ●	kWh/pulse
Active power, delivered	kWh_{L1}					■ ●	kWh/pulse
Active power, delivered	kWh_{L2}					■ ●	kWh/pulse
Active power, delivered	kWh_{L3}					■ ●	kWh/pulse
Reactive power, consumption	$kvarh_{total}$	■ ●	■ ●	■ ●	■ ●	■ ●	kvar/pulse
Reactive power, consumption	$kvarh_{L1}$					■ ●	kvar/pulse
Reactive power, consumption	$kvarh_{L2}$					■ ●	kvar/pulse
Reactive power, consumption	$kvarh_{L3}$					■ ●	kvar/pulse
Reactive power, delivered	$kvarh_{total}$	■ ●	■ ●	■ ●	■ ●	■ ●	kvar/pulse
Reactive power, delivered	$kvarh_{L1}$					■ ●	kvar/pulse
Reactive power, delivered	$kvarh_{L2}$					■ ●	kvar/pulse
Reactive power, delivered	$kvarh_{L3}$					■ ●	kvar/pulse
Apparent power	$kVAh_{total}$	■ ●	■ ●	■ ●	■ ●	■ ●	kVA/pulse

Table 13/2

▼ Measured variables that can be connected to analog outputs.

■ Measured variables that can be connected to limit monitor or with power metering as metered value to binary output.

● Measured variables or metered values that can all be transmitted via serial RS232 or RS485 interface and indicated or logged, for example on a PC or notebook with SIMEAS T PAR software.

Transfer of measured values

for universal transducer with RS485 interface

The metering points registered by the transducer and passed on with the ASDU depend on the chosen mode of operation. These are listed in the adjacent table. The list conforms to DIN 19244 and VDEW

Data transfer by means of IEC 60870-5-103 file transfer

The contents of the file transfer telegrams conforming to IEC 60870 are completely transparent to the user. All existing measured values can be integrated. It is then left to the respective user program to extract the required data.

	ASDU 140 standard with up to 16 measured values					ASDU 9 with 9 measured values	ASDU 140 with 9 measured values
No.[1]	Single-phase Netw.	3-wire unbalanced	3-wire balanced	4-wire unbalanced	4-wire balanced	4-wire unbalanced	4-wire unbalanced
1	I_{L1}	I_{L1}	I_{L1}	I_{L1}	I_{L1}	I_{L1}	$P_{L1\text{-}N}$
2	$U_{L1\text{-}N}$	I_{L3}	f	I_{L2}	$U_{L1\text{-}N}$	I_{L2}	$P_{L2\text{-}N}$
3	f	f	$U_{L1\text{-}L2}$	I_{L3}	f	I_{L3}	$P_{L3\text{-}N}$
4	$\cos\varphi$	$U_{L1\text{-}L2}$	$U_{L1\text{-}L3}$	$U_{L1\text{-}N}$	$\cos\varphi$	$U_{L1\text{-}N}$	$Q_{L1\text{-}N}$
5	φ	$U_{L2\text{-}L3}$	$U_{L3\text{-}L1}$	$U_{L2\text{-}N}$	φ	$U_{L2\text{-}N}$	$Q_{L2\text{-}N}$
6	S	$U_{L3\text{-}L1}$	$\cos\varphi$	$U_{L3\text{-}N}$	S	$U_{L3\text{-}N}$	$Q_{L3\text{-}N}$
7	P	$\cos\varphi$	φ	U_0	P	P	$\cos\varphi_{L1\text{-}N}$
8	Q	φ	S	f	Q	Q	$\cos\varphi_{L2\text{-}N}$
9	–	S	P	$U_{L1\text{-}L2}$	–	f	$\cos\varphi_{L3\text{-}N}$
10	–	P	Q	$U_{L2\text{-}L3}$	–		
11	–	Q	–	$U_{L3\text{-}L1}$	–		
12	–	–	–	$\cos\varphi$	–		
13	–	–	–	φ	–		
14	–	–	–	S	–		
15	–	–	–	P	–		
16	–	–	–	Q	–		

1) No. corresponds to the metering point in the telegram
Dimensions of measured quantities: V, A, Hz, W, Var, VA

Bus link

SIMEAS T transducer with interface acc. to IEC 60870-5-103

In terms of their design, method of connection and technical data, the transducers are identical to the standard units with an RS232 interface. Instead of the RS232 interface, however, an interface conforming to EAI RS485 is installed for operation on an IEC 60870-5-103 bus. Thus, the transducers are bus-compatible and, as shown in the examples, can be networked.

Bus operation does not have an influence on the output of analog measured quantities via the analog outputs. The units are parameterized with the SIMEAS T PAR software.

Connection example 1
User programs for SIMATIC for linking transducers with an RS485 interface

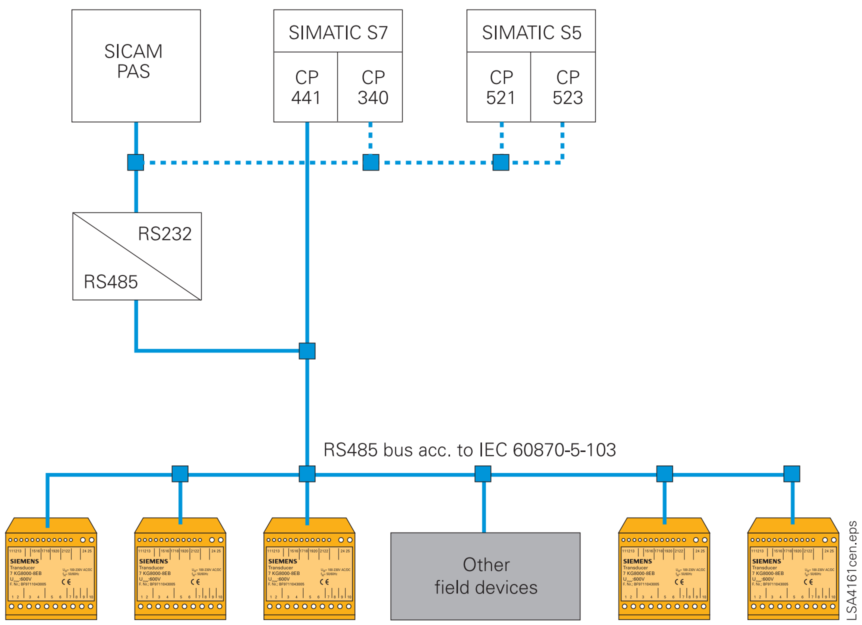


Fig. 13/78 Connection example 1

Bus link

for universal transducer with RS485 interface

Connection example 2

Connection to a PC with the SIMEAS T PAR software

Using the SIMEAS T PAR software, transducers can be called up on the bus and their measured values can be selected on the graphical meters, displayed and recorded.

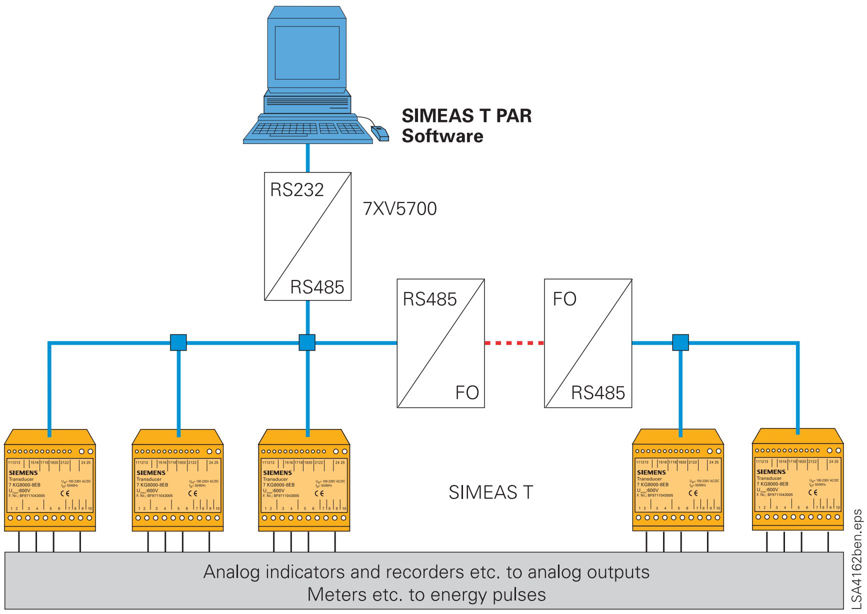


Fig. 13/79 Connection example 2

Parameterization

for universal transducer with RS485 interface

The transducers do not contain any mechanical setting controls. This is why the units must be adjusted for their tasks using a PC or a notebook, the SIMEAS T PAR software and the RS232/RS485 converter prior to use on the bus. To this end, the transducer must be connected to auxiliary power and the RS232/RS485 converter by means of the included plug-in power supply unit.

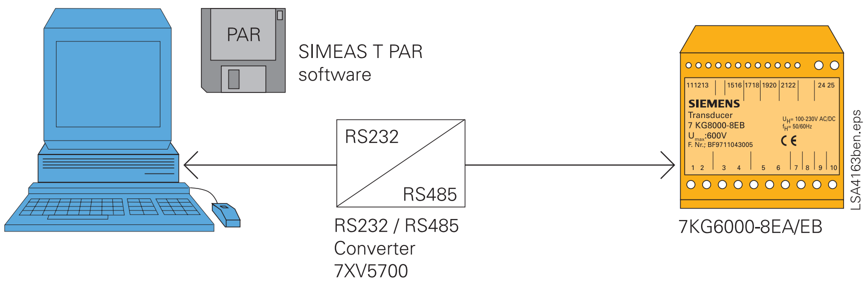


Fig. 13/80

The following are parameterized:

Bus address:	1 to 254
Baud rate:	2400, 4800, 9600 or 19200 bits/s
Basic parameters:	mains type, mains frequency, instrument transformer data
Bus mode:	acc. to IEC 60870-5-103, with 9 or 16 measured values
Analog outputs:	same as standard units (if required)
Binary output:	same as standard units (if required)

Design

for universal transducer with RS232/RS485 interface

Connection examples SIMEAS T connected to a network

The input circuits shown are only examples. Connection without current and voltage transformers is also possible up to the maximum current and voltage values. Voltage transformers can also be connected in a star or V connection.

Inputs or outputs that are not needed for measurement are not connected.

In the case of 3-channel current transducers, for example, only the 3 current inputs need to be connected; in the case of 3-channel voltage transducers, only the voltage inputs need to be connected and, for frequency, for example, only the voltage inputs L_1-N need to be connected. The unit can only be connected to one network or feeder.

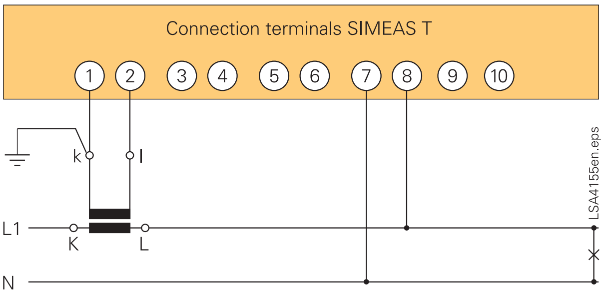


Fig. 13/81
Single-phase AC current

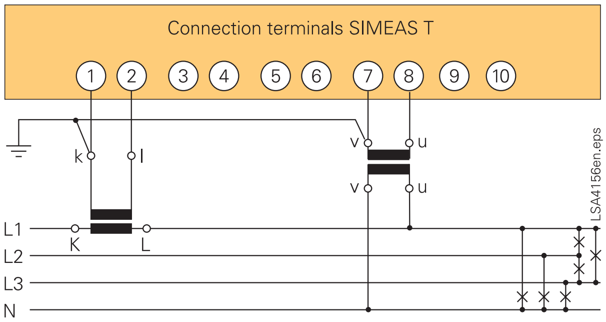


Fig. 13/82
Four-wire three-phase, balanced

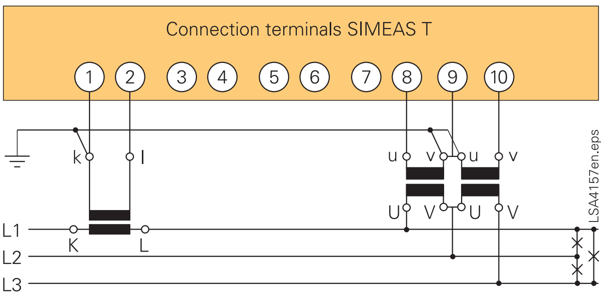


Fig. 13/83
Three-wire three-phase, balanced

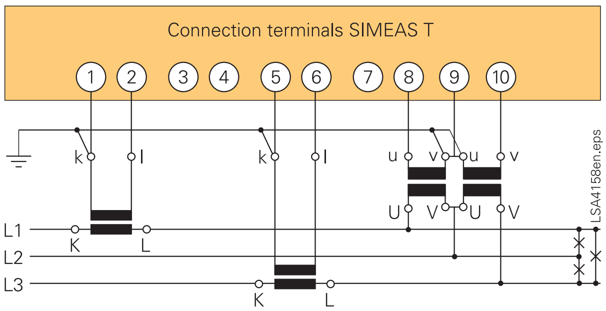


Fig. 13/84
Three-wire three-phase, unbalanced

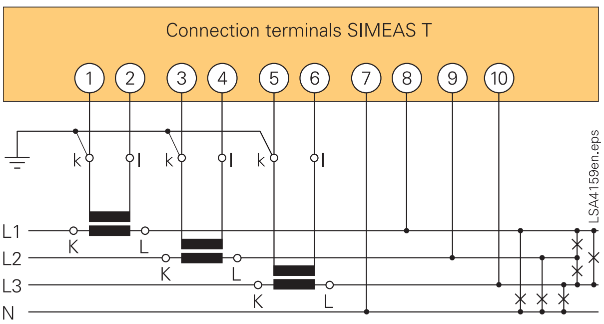


Fig. 13/85
Four-wire three-phase, unbalanced
(high-voltage network)

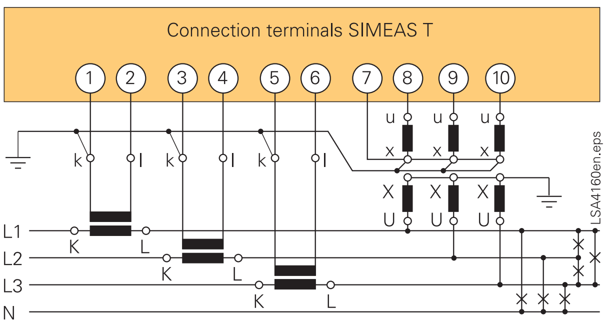


Fig. 13/86
Four-wire three-phase,
unbalanced (low-voltage network)

13

Technical data

for universal transducer with RS232/RS485 interface

Input	
For connection to AC voltage systems only	
Maximum rated mains voltage	Y 230 /Δ 400 V and Δ 500 V
Permissible control range	U_E = 600 V; I_E = 10 A
Rated frequency f_{EN}	50 Hz, 60 Hz, 16 2/3 Hz
Frequency range f_E	50/60 Hz ± 5 Hz
Waveform	sinusoidal or distorted up to the 32nd harmonic
AC input current I_E	
Rated input current I_{EN}	Min. 1 A, max. 5 A
Input range I_E	0 to 10 A
Power consumption per current path	0.01 VA at I_E = 1 A 0.05 VA at I_E = 5 A 0.1 VA at I_E = 10 A
Continuous overload capacity	12 A
Surge withstand capability	200 A for 1 s
Input AC voltage V_E	
Rated voltage V_{EN}	Max. 500 V Δ Max. 288 V Y and single-phase
Power consumption per line V_{L-N}	0.02 VA at $V_E = 100\ V/\sqrt{3}$ 0.33 VA at V_E = 230 V
Continuous overload capacity	V_{L-L} = 600 V
Surge withstand capability	$V_{L-L} \leq$ 850 V / 5 surges 1 s at intervals of 5 s
Analog outputs	
Electrically isolated	Bipolar DC current or DC voltage, short-circuit-proof and idling resistant
Rated output current I_{AN}	20 mA
Rated control range	0 to I_{AN}
Permissible control range	± 1.2 I_{AN}
No-load voltage V_{AL}	≤ 25 V
Rated load R_{BIN}	7.5 V/I_{AN}
Operating load R_B	0 to 15 V/I_{AN}
Rated output voltage V_{AN}	10 V
Rated control range	0 to V_{AN}
Permissible control range	± 1.2 V_{AN}
Short-circuit current	≤ 50 mA
Rated load R_{BIN}	V_{AN} / 2.5 mA
Load current	≤ 20 mA
Residual ripple I_{PP}	≤ 0.5 % PP of I_{AN}
Setting time t_{99}	≤ 0.3 s[1)]
Binary output	
Contact-free via optocoupler	
Permissible voltage	± 100 V DC or 100 V AC
Permissible current	150 mA continuously 500 mA for 100 ms
Internal resistance	≤ 10 Ω
Permissible operating frequency	≤ 10 Hz
Hysteresis at	2 % of int. range limit
Energy pulse range	256 to 7200 pulses/h
Pulse width	App. 100 ms

Interface	
	RS232 (V. 24) optional RS485 acc. to IEC 60870-5-103
Baud rate	2400, 4800, 9600, 19200 Baud adjustable by software Basic standard IEC 60688
Electrically isolated connection	To analog output 1
Auxiliary voltage	Acc. to EN 50082-2
Variant 1:	
Rated output voltage V_{auxN}	24 to 60 V DC
Voltage range V_{aux}	± 20 % of the rated range
Variant 2:	
Rated input voltage V_{auxN}	100 to 230 V AC, 47-63 Hz
Voltage range V_{aux}	± 10 % of the rated range or 110 to 250 V DC
Voltage range V_{aux}	± 20 % of the rated range
Power consumption	1.5 - 3 W depending on the output wiring
Errors and influences	Acc. to IEC 60688
	Relative error information with ± sign
Errors in case of reference conditions	Referred to I_{AN} or V_{AN}
Current, voltage	≤ 0.2 %
Active, reactive, apparent power	≤ 0.3 %
Phase angle	≤ 0.5 %
Power factor	≤ 1 % (measured as from >1% of the internal apparent power)
Frequency	≤ 3 mHz ± 0.2 % of the output range (measured in L1 as from 20 % of the internal voltage range)
Energy	≤ 0.2 %
Reference conditions	
Input current I_E	I_{EN} ± 1 %
Input voltage V_E	V_{EN} ± 1 %
Frequency f_E	f_{EN} ± 1 %
Sinusoidal waveform	Harmonic distortion ≤ 5 %
Load R_B	R_{BIN} ± 1 %
Ambient temperature T_{amb}	23 °C ± 1 °C
Auxiliary voltage V_{aux}	V_{auxN}
Warm-up time	≤ 15 min
Extraneous fields	None
Influences	Referred to A_N
of the input voltage of V_{EN} up to 1.2 V_{EN}	≤ 0.2 %
of the input current of I_{EN} up to 1.2 I_{EN}	≤ 0,2 %
of the auxiliary voltage of 0.8 to 1.2 V_{auxN}	≤ 0.1 %
of the ambient temperature	≤ 0.2 % / 10 K
of the frequency (45 to 65 Hz)	≤ 0.03 % / Hz
of harmonics (up to 32nd harmonic)	≤ 0.02 % per 10 % harmonic distortion
of the load	≤ 0.1 % in the event of a load change for 0 Ω to 15 V/ I_{AN}
heating up	≤ 0.3 %

1) Applicable to measured frequency for Δf/Δt ≤ 8 Hz/s.

13

Technical data

for universal transducer with RS232/RS485 interface

Electrical tests	
Basic standard	IEC 60688
Insulation tests Type tests	Acc. to DIN EN 61010-1
Inputs (currents with respect to one another and to voltages)	3.7 kV, 50 Hz, sine 6.8 kV surge voltage: 1.2/50 µs, R_i = 500 Ω
Inputs to outputs Interface and auxiliary power	5.5 kV, 50 Hz, sine 10.2 kV surge voltage: 1.2/50 µs, R_i = 500 Ω
Auxiliary power to outputs and interface	3.7 kV , 50 Hz , sine 6.8 kV surge voltage: 1.2/50 µs, R_i = 500 Ω
Outputs and interface with respect to one another, and analog output 1 connected to the interface with electrical isolation	700 V DC
Ambient temperature Operating temperature range (depending on measured voltage, output load and method of installation)	Acc. to IEC 60688 -10 °C to + 50 °C e.g. in the case of input voltage 3x100 V and sum of the continuously applied output loads of ≤ 40 mA
Storage temperature range	- 40 °C to + 85 °C
Climatic application class	EN 60721-3-3 temperature 3K8H Humidity 3K5
Fire resistance class	V0
Safety	to DIN EN 61010-1
Surge voltage category	III
Fouling factor	2
Electromagnetic compatibility	
Interference emission	Acc. to DIN EN 50081-1 and IEC/CISPR 22
Radio interference field strength	Acc. to DIN EN 55022 Cl. B
Interference immunity	Acc. to EN 50082-2 and IEC / EN 61000-4
Interference immunity electromagnetic fields 10 V/m	Acc. to IEC 801-3
Static discharge electricity ESD 8 kV	Acc. to IEC 801-2
Fast transients, asym. burst 2 kV with cap. link	Acc. to IEC 801-4
Unit design	
Dimensions	See part 16
Degree of protection Housing Terminals	Acc. to DIN VDE 0470 T 1 / IEC 60529 IP 40 IP 20
Connection Current inputs Voltage inputs Outputs/interface	By screw terminals 4 mm^2 2.5 mm^2 2.5 mm^2
Weight	Approx. 0.65 kg

SIMEAS T PAR

Parameterization software

Description

By means of the SIMEAS T PAR software, SIMEAS T transducers with an RS232 or an RS485 interface can be parameterized or calibrated swiftly and easily. Measured quantities can be displayed on the PC on-line via a graphical meter or can be recorded and stored over a period of up to one week.

Generally, all the transducers are already calibrated and factory set when delivered.

Recalibration of the transducers is normally only necessary after repairs or in the event of readjustment.

Features

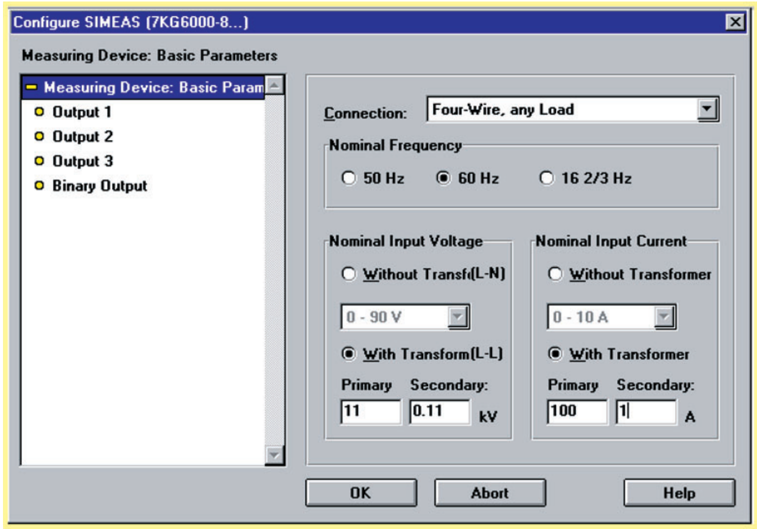
- Extremely simple and straightforward operation
- Storage of parameterization data under a user-defined name even without the transducer
- Parameters are sent to transducers even after installation on the site
- A parameterization list with the specific connection diagram of the transducer can be printed
- A self-adhesive data plate can be printed and fixed to the transducer, including a possibility of entering three lines of text containing the name and location etc.

Parameterization

Parameterization serves to set the transducer to the required measured quantities, measuring ranges and output signals etc. Users are able to parameterize the transducer themselves in only a few steps.

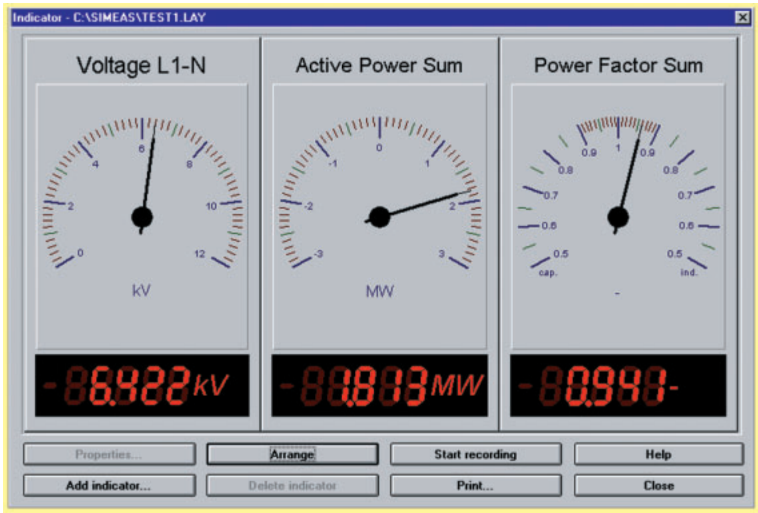
Communication

Communication with the transducer is achieved by means of a connecting cable (optionally available) connected via the interface that is available on every PC or laptop. For units with an RS232 interface, use the connecting cable 7KG6051-8BA or, for units featuring an RS485 interface, use the converter 7XV5700. Three mutually independent program sections can be called up.



SR40148.tif

Fig. 13/87
Parameterization of the basic parameters



SR40152.tif

Fig. 13/88
Measured value display with 3 measured quantities

Reading out data

With graphical instruments, all measured quantities calculated in the transducer and power quantities can be displayed online on a PC or laptop, and either in analog or digital form.

To improve the resolution of the graphics, users can freely choose the number of instruments on the screen and can freely assign the measured quantity and measuring range.

These are selected and assigned independently of the unit's analog outputs.

Displayed measured values can be stored, printed or recorded for the EVAL evaluation software.

13

SIMEAS EVAL

Evaluation software

Description

With a PC or a notebook and the SIMEAS T PAR software installed on it, up to 25 measured quantities can be displayed and recorded online with the SIMEAS T digital transducer. A maximum of one week can be recorded. Every second, one complete set of measured values is recorded with time information. The complete recording can then be saved under a chosen name.

Using the SIMEAS EVAL evaluation software, the stored values can be edited, evaluated and printed in the form of a graphic or a table.

SIMEAS EVAL is a typical Windows program, i.e. it is completely window-oriented and all functions can be operated with the mouse or keyboard.

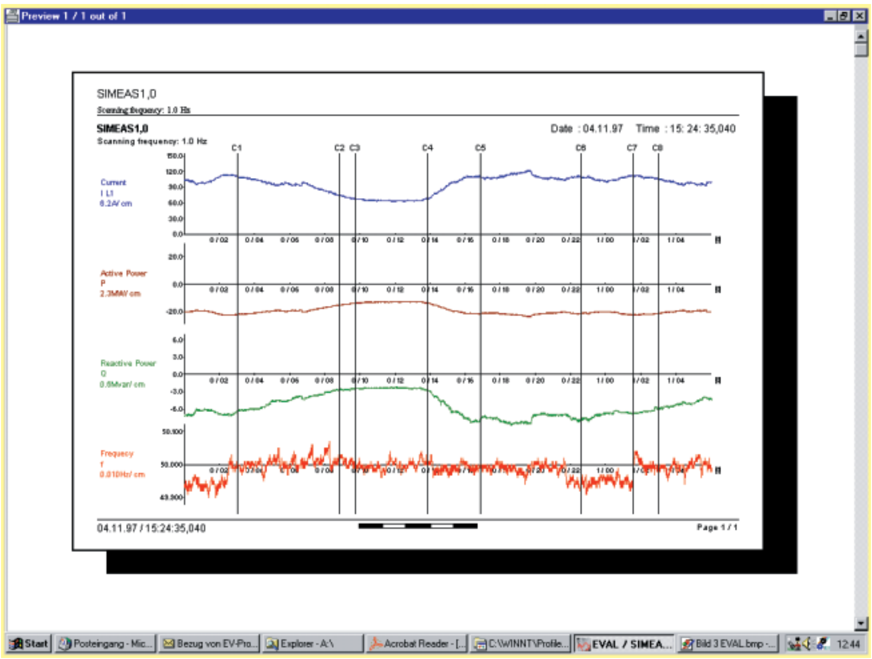
SIMEAS EVAL is installed together with SIMEAS T PAR and is started by double clicking on the EVAL icon. A window containing the series of measurements recorded by SIMEAS T PAR is displayed for selection.

Features

- Automatic diagram marking
- Graphic or tabular representation
- Sampling frequency: 1 s
- A measured value from the table can be dragged to the graphic by simply right-clicking on it
- Add your own text to graphics
- Select measured quantities and the measuring range
- Easy zooming with automatic adaption of the diagram captions on the X and Y axes
- Up to 8 cursors can be set or moved anywhere
- Tabular online display of the chosen cursor positions with values and times
- Characteristics can be placed over one another for improved analysis
- The sequence of displayed measured quantities can be selected and modified
- The complete recording or edited graphic can be printed, including a possibility of selecting the number of curves on each sheet
- The table can be printed with measured values and times pertaining to the cursor positions.

SR40156.tif

Fig. 13/89
When a cursor is moved by the mouse, the measured values and times in the table are adapted automatically



SR40157.tif

Fig. 13/90
Printout view

13

Selection and ordering data

Description	Order No.
SIMEAS T	*7KG6000 – 8A□*
Universal transducer with RS232 interface for self-parameterization via SIMEAS T PAR Windows software	
Auxiliary power	
24 to 60 V DC	*A*
110 to 230 V AC/DC	*B*
SIMEAS T	*7KG6000-8E□*
Universal transducer with RS485 interface for self-parameterization via SIMEAS T PAR Windows software	
Auxiliary power	
24 to 60 V DC	*A*
100 to 230 V AC/DC	*B*
PC connecting cable for parameterization of the transducer with RS232 interface with a 9-pin connector on the PC side (connecting cable provides galvanic isolation between device and PC without auxiliary supply)	*7KG6051-8BA*

Accessories

Description	Order No.
SIMEAS T PAR parameterization software Languages can be chosen during installation: English, German, French, Spanish, Italian	*7KG6050-8AA*
SIMEAS EVAL evaluation software with SIMEAS T PAR Languages can be chosen during installation: English, German, French, Spanish, Italian	*7KG6050-8CA*
RS232/RS485 converter For parameterization of the transducer with a 9/25-pin connector on the PC connecting cable on the transducer and 230 V plug-in power supply unit	
V_{aux} 230 V AC	*7XV5700-0CB00*
V_{aux} 110 V AC	*7XV5700-1CB00*

13

SIMEAS Q
Power Quality Recorder

LSP2007-afp.tif

Fig. 13/91
SIMEAS Q

Function overview

Features

- Recorder for all data required for analysis of the quality of the product “electricity”
- Compact design in assembly housing
- Long-distance data transmission using various communication routes
- Measurement data buffer for up to 70,000 measured values each with time stamp
- Measurement and recording of up to 250 measured variables simultaneously
- Suitable for monitoring single-phase power supply networks and three or four-wire three-phase AC networks
- Continuous and/or event-controlled recording of up to 250 different measured variables
- 2 relay outputs

Possible measured values

- R.m.s. values of phase voltages
- R.m.s. values of phase currents
- System frequency
- Active, reactive and apparent power, as well as power factor per phase and for the overall system
- Balance factor of currents and voltages
- Flickers
- Harmonic voltages and harmonic currents up to the 40th harmonic
- Total harmonic distortion (THD)
- Active, reactive and apparent output of the overall system

Communication interfaces

- Serial RS232 and RS485 interface for direct and modem connections with up to 115200 bps
- Standards-compliant PROFIBUS-DP interface for connection to programmable controllers or PC with up to 12 Mbps

Description

SIMEAS Q is a compact, cost-effective power quality recorder and has been developed to provide full-area monitoring of power quality according to EN 50160 and IEC 61000 standards.

The increasing use of non-linear energy consumers or unbalanced loads has a huge impact on the network quality of the electrical power supply. Many electrical devices in the industry need a proper power supply for accurate operation. A poor quality of the power supply affects the operational reliability inside a network of different consumers and can lead to a cost-expensive loss of the availability of different devices, for example NC machines. Therefore a coverage acquisition und evaluation of the quality of energy supply is necessary.

SIMEAS Q devices are installed at various measuring points in order to record a series of measurements of the required values for an analysis of the network quality. In addition to all relevant measured variables, the SIMEAS Q can also record system disturbances, always when an upward or downward limit value violation has occurred. The recorded values can be called up and evaluated using a PC.

SIMEAS Q is available in 3 device versions with the following communication interfaces:
– RS232
– RS485
– PROFIBUS-DP

Furthermore the device version SIMEAS Q with PROFIBUS-DP interface opens up another area of application. Together with programmable control systems (PLCs), it can be used as a “sensor” for electrical measured variables.

The basic task of data transmission and archiving for several SIMEAS Q devices is automatically managed by the “SICARO Q Manager” software installed on the PC, whereby the data transmission route between the individual SIMEAS Q devices and the PC can be achieved in a number of ways.

The SICARO PQ is a software product for evaluating measured values with respect to international standards, e.g. EN 50160 or IEC 61000 or according to definable compatibility levels. For analysis with SICARO PQ, the measured values are automatically first fetched and stored by SICARO Q Manager software. SICARO PQ automatically accesses the stored measured values and automatically initiates event analysis and reporting and the output in the form of HTML, print or report file.

Connection

Different connection methods or system configurations are possible, depending on the application and existing infrastructure. One is to use a central PC as the master. It is then possible to set up a system for measured-value acquisition and evaluation using the SICARO Q-Manager software. For long distances individual devices or the complete RS485 bus with Ethernet converter may be used. An other possibility is to link up to a PLC system where the SIMEAS Q is connected to the central master as a slave.

The PROFIBUS interface, implemented and certified according to standard EN 50170 Volume 2, enables fast adaptation to a PLC systems. That way, measured values acquired with the SIMEAS Q can be used for control tasks.

Detailed information on how to retrieve measurement data from SIMEAS Q via PROFIBUS is available to everyone in the SIMEAS Q user description[1)]. The open communication interface permits data transmission between SIMEAS Q units and all types of PROFIBUS-DP Masters, such as programmable controllers or personal computers (with integrated PROFIBUS-DP hardware).

Function blocks are available for the SIMATIC S7-300 and S7-400 PLC systems, with an internal or external DP interface[1)].

They permit fast configuration of customer-specific PLC programs for applications combining SIMEAS Q with these PLC systems.

Functions

Recording of measured values is possible in two modes, which can be used simultaneously.

- Continuous recording
- Recording in the case of a limit value violation

In “continuous recording“ mode, the SIMEAS Q can record measured quantities as defined in the standards (e.g. EN 50160). Acquisition of maximum and minimum values of measured quantities within the measurement period (averaging time) is also possible.

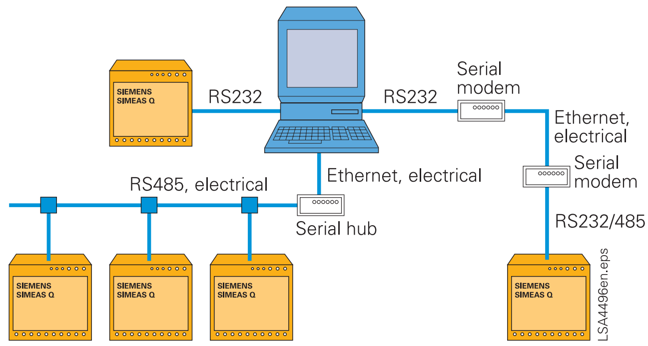


Fig. 13/92
Using the SICARO Q Manager software and a PC with several SIMEAS Q units

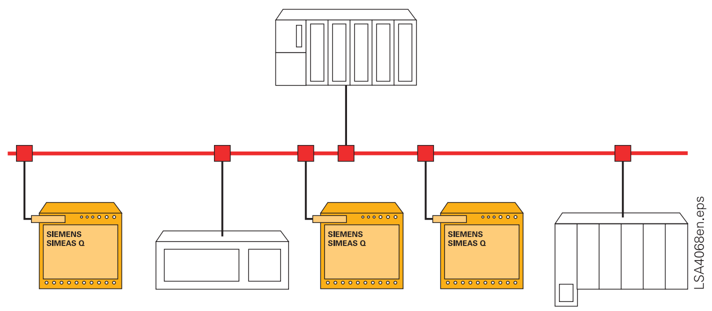


Fig. 13/93
SIMATIC S7 PLC as the master station with various PROFIBUS-DP slaves

“Recording in the case of limit value violation” means that measurement data are recorded when the average measured value violates one or more defined upper or lower limits (thresholds). When a limit value is violated, the current time and date information and the mean value since the last limit value violation of that measured quantity are stored in the memory. This type of recording is primarily used for recording voltage dips. To record voltage dips, the lowest possible averaging time of 10 ms is selected. During measurement, the SIMEAS Q compares the rms values = 10 ms with the set thresholds and is thus able to record very short voltage dips.

Relay outputs

The SIMEAS Q is fitted with 2 relay outputs (opto-relays). One of the following functions can be assigned to these outputs:

- Indication device active (switched on)
- Energy metering pulse per settable energy value for:
  - Active energy, energy import
  - Active energy, energy export
  - Reactive energy, capacitive
  - Reactive energy, inductive
  - Apparent energy
- Indication active power import (contact open) or active power export (contact closed)
- Limit power factor (PF (cos φ)) (contact closed for as long as PF is lower than a settable limit value)
- Pulses an voltage dips (contact closed for 500 ms if violation of the threshold below rated voltage detected)

The relay outputs enable the SIMEAS Q to be used for acquisition of measured values and for energy metering.

1) www. simeas.com

Software

The SIMEAS Q PAR software and SICARO Q Manager software can be downloaded free of charge via the Internet at www.powerquality.de or www.simeas.com.

If SIMEAS Q units are connected to a PLC system as slaves, only the SIMEAS Q PAR software is required to set the SIMEAS Q parameters.

To configure the SIMEAS Q, a cable is required to connect the PC. A separate parameterization package is available for this, containing the parameterization software and the connecting cable required for the respective unit version.

SIMEAS Q PAR configuration software

The SIMEAS Q PAR parameterization software is executable under the Windows 2000/XP operating systems. The software allows you to define the device address, so that each device is uniquely identified and to configure the SIMEAS Q for the communication protocol to be used (RS232, RS485 or PROFIBUS DP) in order to prepare it for the measurement task.

SICARO Q Manager – software for measured-value acquisition

The SICARO Q Manager software, executable under the Windows 2000 / XP operating systems, is a software product for configuring a system with several SIMEAS Q units and for gathering the measured values from the SIMEAS Q units, displaying them, storing them in PQ archives and making them available for further processing.

- Functional scope
  - Graphic configuration of a system structure with the connected SIMEAS Q units.
  - Automatic transmission and storage of the measurement data from the connected units.
  - Display of retrieved measurement data. The display takes the form of rotary dial instruments, bar charts and numerical values.

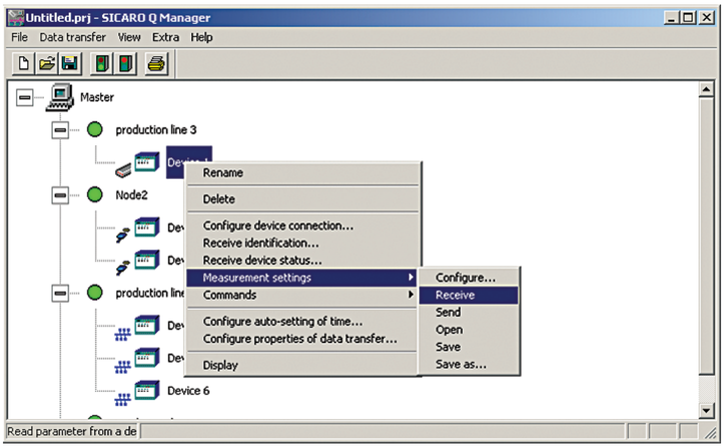


Fig. 13/94
SICARO Q Manager
Main menu with system structure
Menu item for measurement settings

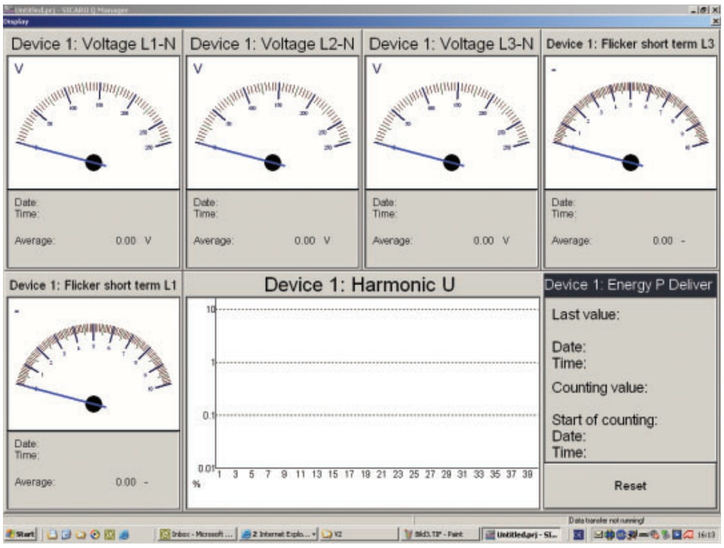


Fig. 13/95
SICARO Q Manager
Display of the currently transmitted measured values

  - Automatic, cyclic time setting of all connected units to align the SIMEAS Q's internal clock with the system time of the PC.
  - Automatic conversion of stored measurement data for analysis with the SICARO PQ software.
  - Conversion of stored measurement data to ASCII format. After conversion, the data can be further processed with suitable software, e.g. Microsoft Excel.

13

Software

SICARO PQ - the analyzing tool

The SICARO PQ software, executable under the Windows 2000 / XP operating systems, is a software product for evaluating measured values based on international standards, e.g. EN 50160 or IEC 61000 or according to customer-specific compatibility levels. For analysis with SICARO PQ, the transmitted measured values first have to be archived using the SICARO Q Manager software. The archived data are then the data source for the analysis software. For evaluation and reporting, the reference levels have to be applied and a reporting template has to be selected.

Evaluation procedure

- Manual selection of data archive
- Manual selection of measured quantities and time range
- With selected settings for analysing reports (quality profiles) by using of functional task scheduler it is possible to create automatic jobs for printing reports or creating reports in HTML format.

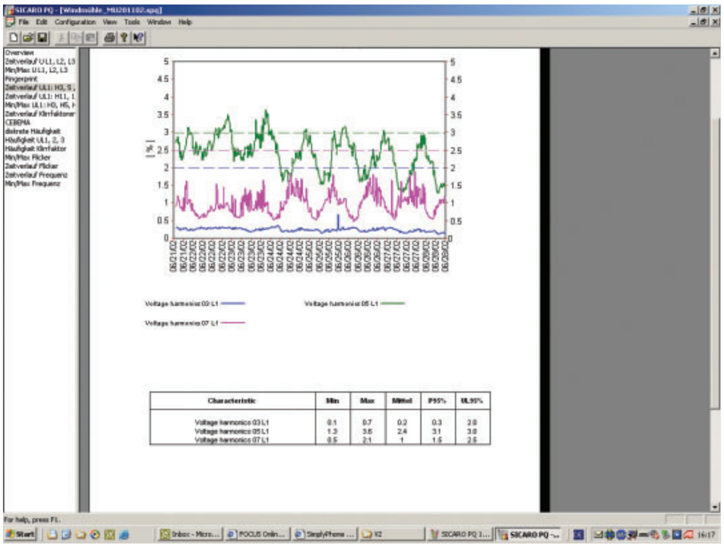


Fig. 13/96 SICARO PQ
Display and analysis of continuous measured values

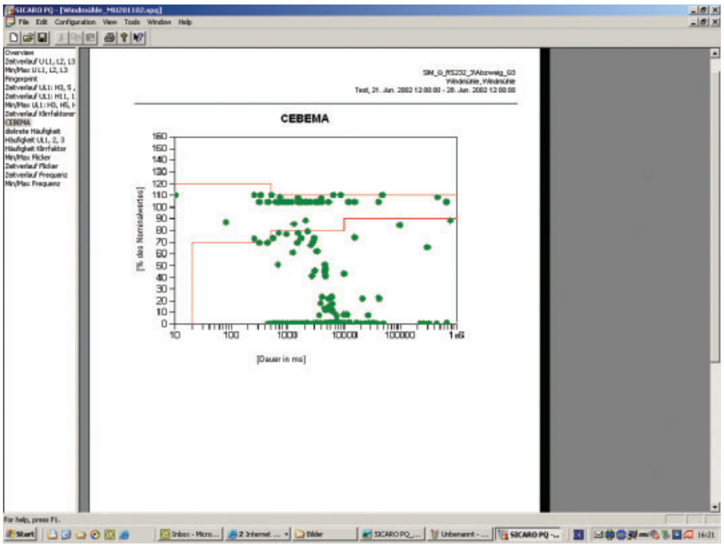


Fig. 13/97 SICARO PQ
Analysis of voltage dips using a CBEMA plot

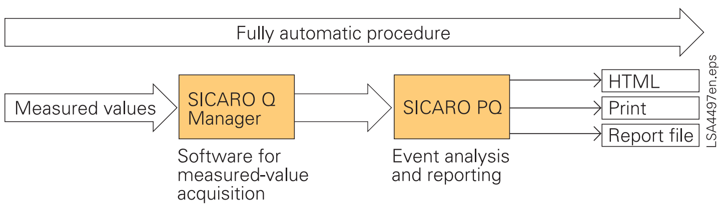


Fig. 13/98 For regular reporting, e.g. every day, every week, every month, every year the Windows Task Scheduler is used

Connection examples

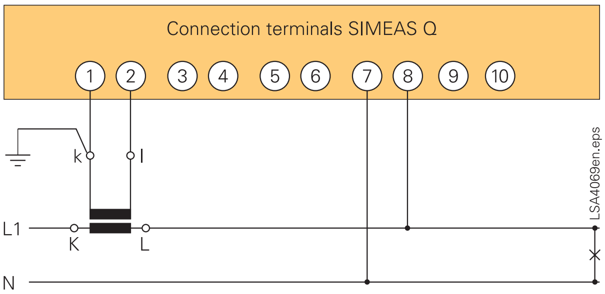


Fig. 13/99
Single-phase alternating current

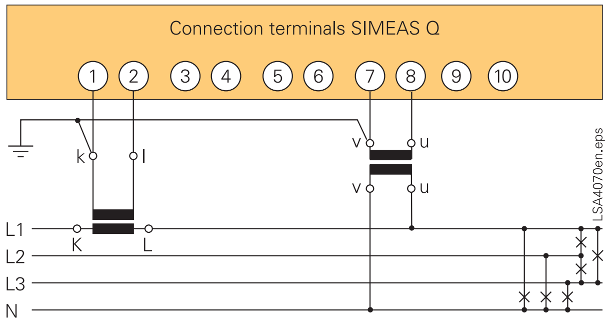


Fig. 13/100
Four-wire three-phase current, same load

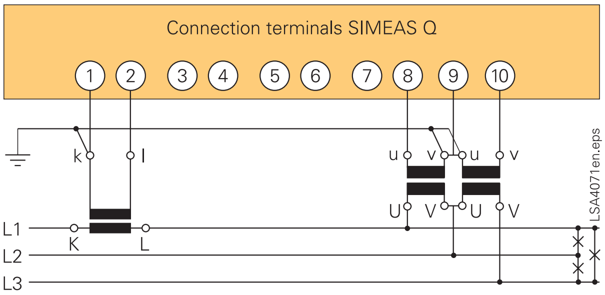


Fig. 13/101
Three-wire three-phase current, same load

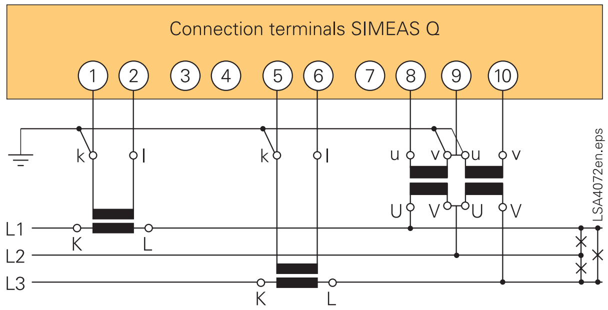


Fig. 13/102
Three-wire three-phase current, any load

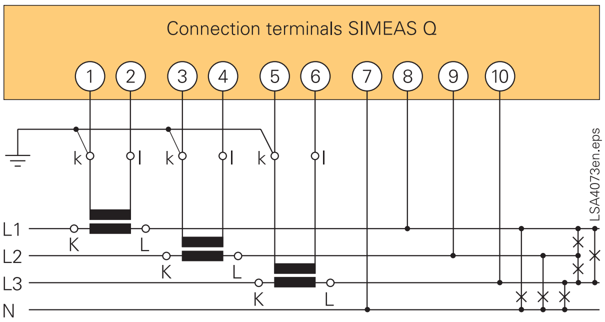


Fig. 13/103
Four-wire three-phase current, any load (low-voltage network)

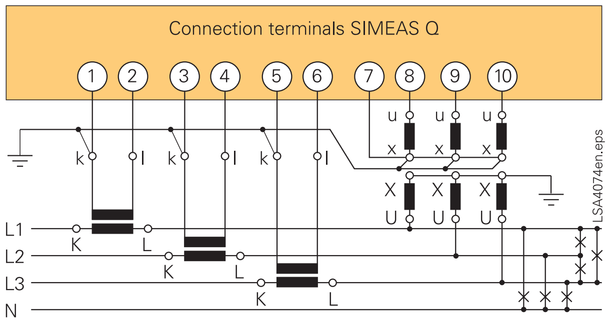


Fig. 13/104
Four-wire three-phase current, any load (high-voltage network)

The input connections shown above are only examples. Currents and voltages up to the maximum permissible values can be connected even without current and voltage transformers.

Voltage transformers can also be connected in a delta or wye connection. All input or output terminals not needed for measurement remain unconnected.

Technical data

Input	
	For connection to AC systems only
Maximum rated system voltage	Y 230/Δ 400 V
Permissible dynamic range	V_Y = 280 V; I_E = 6 A
Rated frequency f_{EN}	50 Hz, 60 Hz
Frequency range f_E	± 5 Hz
Waveform	Sinusoidal or distorted up to 40th harmonic
Input alternating current I_E	
Input rated current I_E	Min. 1 A; max. 6 A
Power consumption per current path	Approx. 0.06 VA at I_E = 6 A
Dynamic range	6 A
Continuous overload	12 A
Surge withstand capability	200 A acc. to IEC/EN 60688
Input alternating voltage V_E	
Power consumption	0.02 VA at V_{EN} = 100 V / $\sqrt{3}$
Input to ground	0.33 VA at V_{EN} = 230 V
Rated voltage V_{EN}	Max. 230 V (3-phase)
Continuous overload	1.2 x V_N = 280 V
Surge withstand capability	2 x V_N = 460 V acc. to IEC/EN 60688
Auxiliary voltage	
	Multi-range PSU AC/DC
Rated voltage variant 1	24 to 60 V DC
Permissible tolerance range	± 20 % of the rated voltage
Rated voltage variant 2	110 to 250 V DC and 100 to 240 V AC / 45 to 65 Hz
Permissible tolerance range	+15/-20 % of the rated voltage
Power consumption	3.5 W per connection
Binary outputs	
	2 via opto-relays
Permissible voltage	± 100 V AC/DC
Permissible current	150 mA permament 500 mA for 100 ms
Internal resistance	≤ 10 Ω
Permissible switching frequency	10 Hz
Measurement functions	
Number of channels	3 voltage inputs with common neutral N 3 current inputs
Calculation method	Fast Fourier transform
Sampling rate	6400 Hz for 50 Hz system frequency 7680 Hz for 60 Hz system frequency per voltage or current input
Resolution	14 bits
Voltage	
Measuring range	0 to 280 V
Accuracy	Typically ≤ 0.1 % of rating
Storage	Continuously independently selectable averaging time 1 to 3600 s storage of max., min. and average values possible On limit value violation independently selectable averaging time 10 ms to 3600 s 5 settable limits

***Measurement functions** (continued)*	
Current	
Measuring range	0 to 6 A
Accuracy	Typically ≤ 0.1 % of rating
Storage	Continuously independently selectable averaging time 1 to 3600 s storage of max., min. and average values possible On limit value violation independently selectable averaging time 10 ms to 3600 s 5 settable limits
Active power, apparent power, reactive power	
Accuracy	Typically ≤ 0.2 % of rating
Storage	Continuously independently selectable averaging time 1 to 3600 s storage of max., min. and average values possible On limit value violation independently selectable averaging time 1 to 3600 s 2 settable limits each
Power factor	
Accuracy	Typically ≤ 0.2 %
Storage	Continuously independently selectable averaging time 1 to 3600 s storage of max., min. and average values possible On limit value violation independently selectable averaging time 1 to 3600 s 2 settable limits
Symmetry	
Measurement	For measurement in 3-phase system voltage and current
Accuracy	Typically ≤ 0.2 %
Storage	Continuously independently selectable averaging time 1 to 3600 s storage of max., min. and average values possible On limit value violation independently selectable averaging time 1 to 3600 s 2 settable limits
Frequency	
Accuracy	≤ 5 mHz
Storage	Continuously independently selectable averaging time 1 to 3600 s storage of max., min. and average values possible On limitv value violation independently selectable averaging time 1 to 3600 s 2 settable limits
Harmonics	
Frequency range	Up to 40th harmonic per voltage or current input
Accuracy	Acc. to IEC 61000-4-7 Class B
Storage	Continuously independently selectable averaging time 1 to 3600 s storage of max., min. and average values possible On limit value violation independently selectable averaging time 1 to 3600 s 2 settable limits per harmonic
Flicker factor	
Measurement	A_{St}/A_{lt} or P_{St}/P_{lt} per voltage input
Accuracy	Acc. to IEC 61000-4-15 (IEC 60 868)
Storage	Continuously averaging time A_{st} and P_{st} 10 min averaging time A_{lt} and P_{lt} 120 min

13

Technical data

Measurement functions *(continued)*	
Active energy, import Active energy, export Reactive energy, capacitive Reactive energy, inductive Apparent energy Accuracy Storage	 Typically ≤ 0.2 % Continuously, selectable averaging time 1 to 60 min
Electrical tests	
Stress tests	Acc. to IEC/EN 61010-1
Dielectric test	Acc. to EN 61010-1
Input circuits against each other	3.7 kV, 50 Hz, 1 min
Aux. voltage against interface and relay outputs	3.7 kV, 50 Hz, 1 min
Input circuits against interface and relay outputs	5.55 kV, 50 Hz, 1 min
Impulse voltage withstand test	Acc. to EN 61010-1
Input circuits against each other	6.8 kV, 1.2/50 µs
Aux. voltage against interface and relay outputs	6.8 kV, 1.2/50 µs
Input circuits against interface and relay outputs	10.2 kV, 1.2/50 µs
Temperature and climatic stress	Acc. to IEC/EN 60688 -10 °C to 55 °C, no condensation during operation
Industrial atmosphere	
SO_2	Acc. to IEC 60068-2-42 DIN 40046 Part 36
H_2S	Acc. to IEC 60068-2-43 DIN 40046 Part 37
Mechanical stress	
Vibrations, sinusoidal stationary use	Acc. to IEC 60068-2-6, IEC 60255-21-1
Vibrations, sinusoidal transportation	Acc. to IEC 60068-2-6, IEC 60255-21-1
Seismic stress stationary use	Acc. to IEC 60068-3-3, IEC 60255-21-3
Shock, half-sine wave, stationary use	Acc. to IEC 60068-2-27, IEC 60255-21-2
Shock, half-sine wave, for resistance	Acc. to IEC 60068-2-27, IEC 60255-21-2
Shock, half-sine wave, continuous shock	Acc. to IEC 60068-2-29, IEC 60255-21-2
Safety	
Mechanical resistance to shock and impact	Acc. to IEC 61010-1, IEC 60068-3-75
Degree of protection Housing Terminals Safety class	 IP 40 IP 20 Safety class 1
Temperature and protection from propagation of fire	Acc. to IEC 60255-6, IEC 61010-1
Insulation Clearance and creepage distance	Acc. to EN 61010-1, pollution degree 2, overvoltage category III

Electromagnetic compatibility	
Immunity	Acc. to EN 61000-6-2, EN 60688
1 MHz burst disturbance test	Acc. to IEC 60255-22-1, 2.5 kV, 400 Hz
Electrostatic discharge	Acc. to IEC 61000-4-2 Class III
Radiated electromagnetic field disturbance test	Acc. to IEC 61000-4-3, ENV 50204
Burst	Acc. to IEC 61000-4-4
Surge	Acc. to IEC 61000-4-5
Conducted disturbances induced by radio-frequency fields	Acc. to IEC 61000-4-6 Class III
Magnetic field	Acc. to EN 61000-4-8 Class IV, IEC 60688, IEC 60255-6
Emission	Acc. to EN 50081-1, EN 50081-2
Conducted interference	Acc. to CISPR 22, EN 55022, VDE 0878 Part 22
Noise field intensity	Acc. to CISPR 11, EN 55011, VDE 0875 Part 11
Disturbances power supply systems	Acc. to IEC 61000-3-3, IEC 61000-3-2

Communication interface	
Interface Connection technique	9-pin SUB-D connector female
Transmission options PROFIBUS DP Transmission rate	 From 9 600 Bit/s to 12 MBit/s
RS232 interface Transmission rate	Modem-capable From 300 Bit/s to 115 200 Bit/s
RS485 interface Transmission rate	 From 300 Bit/s to 115 200 Bit/s
Data memory	
2 MB memory for measurement data	Memory up to 70 000 measured values, each with time information
Program memory	256 kByte EEPROM
Real-time clock	
Internal real-time clock Format Deviation Back-up Synchronization and setting	 Year, month, day, hour, minute, second 100 ppm With lithium battery Via communication interface
Unit design	
Dimensions	90 x 75 x 105 mm (W x H x D)
Housing	Snap-on housing for DIN rail mounting Degree of protection IP40
Connection elements - Aux. power supply - Voltage inputs - Current inputs - Binary outputs - Communication interface	Degree of protection IP20 Terminal for max. 2.5 mm² Terminal for max. 2.5 mm² Terminal for max. 4 mm² Terminal for max. 2.5 mm² 9 pin SUB-D connector
Weight	Approx. 0.7 kg

Selection and ordering data

Description	Order No.
SIMEAS Q	*7KG8000 – 8□□20*
Interface	
With PROFIBUS-DP interface	*A*
With modem-capable RS232 interface	*B*
With RS485 interface	*C*
Auxiliary voltage	
24 to 60 V DC	*A*
110 to 250 V DC and 100 to 240 V AC 45 to 65 Hz	*B*
SIMEAS Q parameterization package for SIMEAS Q with RS232 interface	*7KG8050-8BC20*
Software SIMEAS Q PAR for configuration and calibration of SIMEAS Q units with an RS232 interface on a PC	
Connecting cable SIMEAS Q to PC Length 4 m	
SIMEAS Q parameterization package for SIMEAS Q with RS485 interface or PROFIBUS DP interface	*7KG8050-8A□20*
Software SIMEAS Q PAR for configuration and calibration of SIMEAS Q units with RS485 or PROFIBUS-DP interface on a PC	
Connecting cable SIMEAS Q to PC incl. RS232/RS485 converter	
Plug-in power supply unit for converter	
Auxiliary voltage	
230 V AC 50 Hz	*A*
110 V AC 60 Hz	*B*
RS232-RS485 converter incl. cable	*7XV5700-□BB00*
Connecting cable SIMEAS Q to PC	
Plug-in power supply unit for converter	
Auxiliary voltage	
230 V AC 50 Hz	*0*
110 V AC 60 Hz	*1*
Ethernet hub for substations	*7XV5655-0BA00*
Serial hub for serial, asynchronous data transmission (for more details see part 14 of SIP Catalog)	
Ethernet modem	*7XV5655-0BB00*
For serial, asynchronous data transmission (for more details see part 14 of SIP Catalog)	

13

Selection and ordering data

Description	Order No.
Software	
SICARO Q Manager incl. SIMEAS Q PAR	*7KG8000-5BB20-0A*□*1*
Delivered on CD-ROM	
Manual	
German	*A*
English	*B*
SICARO PQ incl. SICARO Q Manager and SIMEAS Q PAR	*7KE6000-5GE*□
Software for analysis of network quality	
Complete license on CD-ROM with manual in English and German	*2*
Update version on CD-ROM only for an update of an existing SICARO PQ installation/license to the current released version. Send the old order number	*4*

SIMEAS R
Disturbance Recorder and Power Quality Monitoring Unit

LSP2413-afp.tif

Fig. 13/106

Description

SIMEAS R is a powerful disturbance (transient) recorder, power quality monitoring unit, power and frequency recording system, and event recorder. All these features are independent and run in parallel. The disturbance recorder with a high sampling rate and excellent frequency response enables precise analysis of network disturbances. The power quality monitoring system for recording of voltage and current r.m.s. values, frequency, real and reactive power, power factor, current and voltage harmonics, voltage sages and swells, voltage flicker, etc. is a reliable tool to monitor and archive power quality related events. The power and frequency recording system is an important equipment in power plants to understand stability problems and analyze related topics like the response of generator excitation control systems. With an event recorder, various digital signals like the status of a breaker, isolator, and trip contacts of protection relays, etc. can be observed and recorded for further analysis. SIMEAS R as a field unit forms with OSCOP P software installed on a DAKON PC (personal computer for data collection) a powerful disturbance recording system. One DAKON PC can communicate with several SIMEAS Rs using various communication channels. In the “Automatic mode”, the DAKON PC is able to collect all data recorded by SIMEAS Rs.

With a flash memory of 512 MB for each SIMEAS R and practically unlimited storage capability on DAKON PCs and with a powerful database, the recording system enables excellent archiving possibilities.

The data obtained by SIMEAS R is written to a high-capacity internal bulk storage medium. Under normal conditions in substations, power plants and industrial systems, this type of storage takes months to fill up. When storage is full, it functions as a "ring buffer", overwriting the oldest values with the latest figures.

With a high sampling rate (256 samples per cycle), this unit records all relevant information for further analysis of short-circuits, breaker opening and closing behavior, reaction of CTs and VTs on network disturbances, etc. With a recording capability of 32 analog and 64 binary channels of each unit and with real-time synchronization capability, the system can observe and monitor a huge number of feeders and power equipment.
SIMEAS R is a recorder meeting all electromagnetic compatibility requirements like all Siemens numerical relays. High level of hardware and software quality and precise self diagnosis of each unit is a guarantee for the investment of our customers.

Function overview

- Disturbance recorder for applications in substations at MV/HV/EHV level and in power plants
- Power and frequency recorder for applications in power plants
- Power quality recorder for analysis and recording/archiving of power quality problems of all power applications
- Event recorder for binary signals for observation of the status of various primary components like breakers, isolators, etc.
- Transient recorder for DC signals
- Test recorder for commissioning and system test

Powerful recording system

- The field units SIMEAS R and the PC software OSCOP P form a powerful disturbance recording and power quality monitoring system. With a DAKON PC (Personal computer for data collection) in automatic mode, powerful data collection and archiving capability leads to very short analysis times
- Communication capability via Ethernet (LAN or WAN structure) in accordance with Ethernet 802.3 using TCP/IP protocol, communication via telephone network using ISDN or analog modem or direct communication using copper (RS232) or fiber-optic channels
- Various installation possibilities of the PC software OSCOP P in server, client and evaluation mode meet all requirements, like visualization, analysis for parameterization, commissioning, test, automatic data collection, data archiving
- Precise fault location capability using OSCOP P & diagnosis software
- Detailed power quality analysis information using SICARO PQ software

Powerful hardware

- Modular hardware system with up to 32 analog and 64 binary inputs in a 19-inch rack
- Flash memory with 512 MB

System Overview

The DAKON is an industrial PC to which two or more SIMEAS R and numerical relays with the IEC 60870-5-103 protocol can be connected. In “automatic mode”, a DAKON can automatically fetch both data from SIMEAS R and the fault recordings from protection equipment, and write these to its own storage. Communication between the SIMEAS R, a DAKON and evaluation PCs is possible in various ways, for example via a wide area network (WAN) or local area network, with the TCP/IP protocol and electric or optical cables, as well as with converters and hubs. As an alternative, communication via analog or ISDN modems with a star coupler is also possible.

Time synchronization

To enable a comparison of recordings from fault recorders and protection equipment at different locations, precise time synchronization of all SIMEAS R and DAKON devices is necessary. This is ensured by the use of additional components, such as GPS or IRIG-B receivers and the synch box module.

Analysis and evaluation software

All data recorded with SIMEAS R can be analyzed with the OSCOP P software package. OSCOP P is also used for parameterizing the SIMEAS R and archiving the fault recordings and mean values.

The DIAGNOSE software module is an optional additional package for OSCOP P, serving to work out the location of a fault in a line. Depending on data availability, the program can use fault recordings made at either end of a line to determine the fault location. The measured values recorded with the “mean value and power quality recorder” function can be analyzed with the SICARO PQ software package. For example, information can be obtained about the system voltage quality on a specific feeder.

Design and data acquisition units

The SIMEAS R recorder is available in two different housings. The smaller type (ZE8/16) can be equipped with one data acquisition unit (DAU). The larger type (ZE32/64) provides space for up to 4 DAUs. A selection of different DAUs enables flexible arrangement of inputs for current, voltage and DC voltage:

– VDAU (8 voltage channels)
– DAU (8 current channels)
– VCDAU (4 voltage and 4 current channels)
– DDAU (8 DC channels)

All data acquisition units described also feature 16 binary channels. If a larger number of binary signals is to be recorded, the recorder can optionally be equipped with a BDAU with 32 binary channels.

Fig. 13/107
SIMEAS R, compact housing

Fig. 13/108
SIMEAS R, front view.
A DAU can be seen in the middle slot

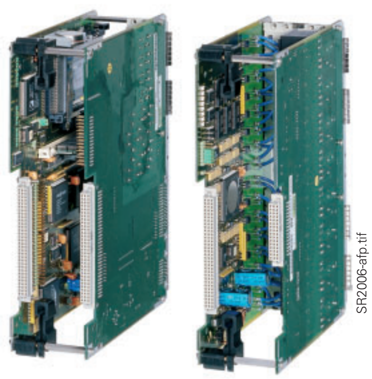


Fig. 13/109
DAUs

13

Functions

Dynamic fault recorder for analog and binary channels

The “fault recorder” function includes recording of analog and digital signals. These signals are continuously recorded and simultaneously compared with the parameterized trigger criteria. On triggering, all channels are recorded concurrently and with a pre-fault, variable fault progression and post-fault, depending on the parameter settings for recording.

Recording alternating current and voltage

Three different data acquisition units are available for recording currents and voltages:

– VCDAU with 4 voltage and 4 current inputs,

– CDAU with 8 current inputs or

– VDAU with 8 voltage inputs.

The sampling rate for recording analog channels is 256 times higher than the system frequency. For a system frequency of 50 Hz, the sampling rate is therefore 12.8 kHz (for 60 Hz, 15.36 kHz per channel).

Recording of the process variables

DC signals are measured via the DDAU data acquisition unit, which has 8 signal inputs. The DDAU can be ordered for an input range of -1 V to +1 V, -10 V to +10 V or -20 mA to +20 mA. These inputs can be assigned to one process signal each, e.g. display of temperature in K, speed of rotation in rpm, voltage in kV, current in kA.

If a recorder contains only DDAUs, it is possible to parameterize the sampling rates 10 Hz / 100 Hz / 1 kHz / 10 kHz. If the recorder also contains other DAUs, the sampling rate of the DC signals is always 10 kHz. To suppress signal disturbance, a digital filter with a settable averaging time can be activated by parameterization.

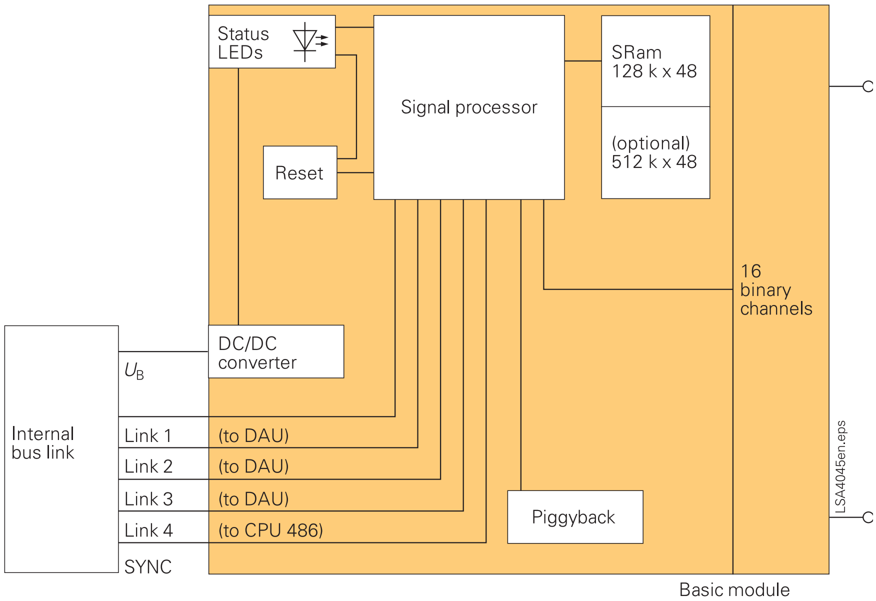


Fig. 13/110
DAU data acquisition unit

Functions

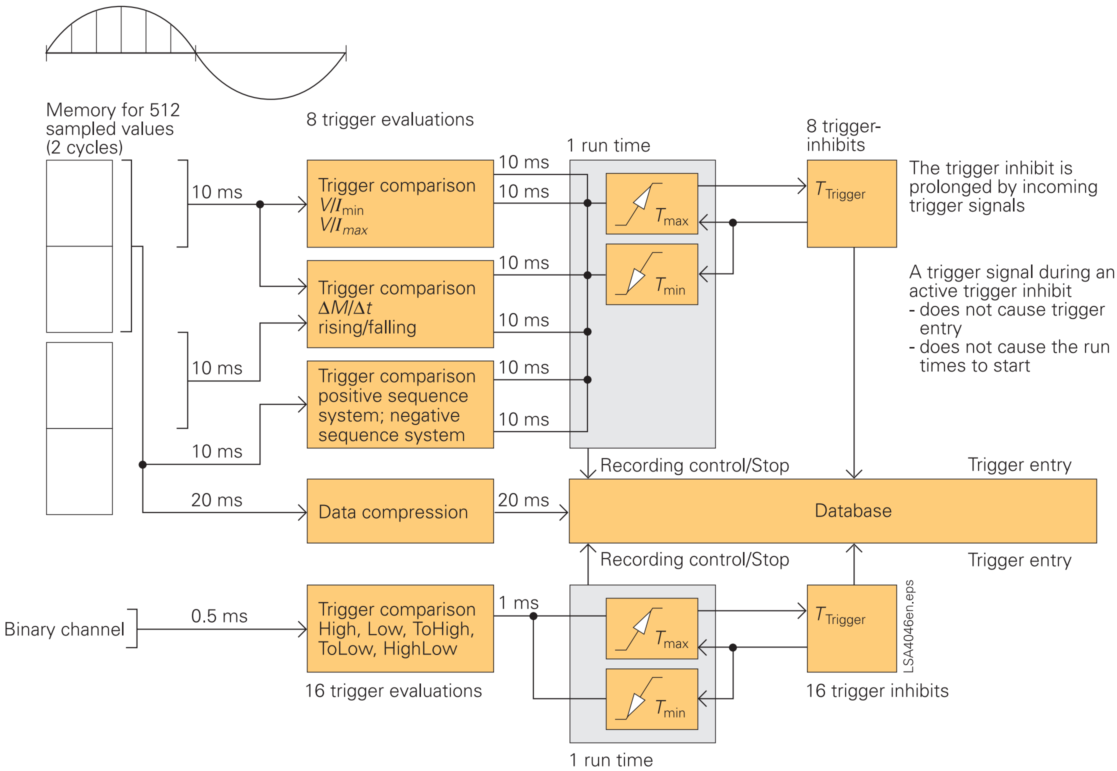


Fig. 13/111
Block diagram of the fault recorder function, trigger function and trigger inhibit

Recording of binary signals

The recording of binary channels is fully synchronized with recording of analog channels. The sampling rate is 2 kHz. A group of 16 binary inputs can record up to 250 state changes per second.

Flexible triggering

With its numerous settable trigger conditions, SIMEAS R can be precisely adapted to the specific requirements of an application:

- Triggering on the rms value of an analog channel (min. / max. triggering)
  For triggering, the recorder calculates a measured value corresponding to the rms value of a current or voltage (I, V) continuously at intervals of half a system cycle. The values sampled over half a system cycle are used to calculate this measured value.

  Triggering occurs (i.e. recording is started) when the measured value either exceeds a positive maximum limit or falls below a positive minimum limit.

  One practical example of this is triggering on a maximum value of the rms current and on a minimum value of an rms voltage.

- Triggering on a change in the rms value of an analog channel (dM/dt triggering)
  Each time the measured value described above (V, I) is calculated, the difference is formed between two measured values one system cycle apart. This difference is compared with the set rate-of-change (dM/dt) limit, e.g. 10 kV / 20 ms. This permits triggering on a positive or negative change to the rms value of a voltage or current input.

- Triggering on the rms value of the positive or negative sequence system (min. / max. triggering)
  The recorder can be parameterized to treat the analog inputs of a data acquisition unit as single, independent channels, or assign them to a three-phase system. In the latter case, positive and negative sequence components can be calculated both for current and voltage channels and used for triggering. Calculation of the measured quantities and of the triggering is performed as described under “Triggering on the rms value of an analog channel, min. / max. triggering”.

Functions

Examples of logic gating:

- Voltage min. trigger threshold, recording reached, and current max.
- Binary contact channel 1 high recording and current max. trigger reached
- Binary contact 1, 3, 4 high and 6, 7, 9 low recording

- Triggering on the limit of a DC channel (min. / max. triggering)
  Triggering is performed when the sampled value of the DC signal exceeds the max. limit or falls below the min. limit.
- Triggering on the gradient of a DC channel (gradient triggering)
  For the gradient trigger, the difference is calculated between two sampled values of a DC signal in a settable time interval. Triggering can be performed on a positive or negative gradient.
- Triggering on binary channels
  Triggering to state (high or low), or on the positive or negative signal edge or on a binary input change is possible.
- Logic gating of trigger conditions
  Analog and binary trigger conditions can be ANDed. The logic gating of triggers serves, for example, to distinguish a fault from an intentional line disconnection. The logic operation is applied to a settable time window from 0 to 1 s. If the triggering conditions are detected as "true" during this time window, recording starts. A total of 8 patterns with 8 start selectors each can be parameterized as trigger criteria.
- Triggering via the front panel (manual trigger)
  This function is especially useful for commissioning work. It permits testing of the polarity of current and voltage channels and testing of phase angle offsets.
- Triggering via PC
  This triggering is identical with the manual triggering but activated from the PC via the OSCOP P software.
- Network trigger
  This triggering applies to devices communicating via an Ethernet network. Triggering is performed either from the PC for all connected SIMEAS R recorders, or sent from a SIMEAS R to further devices.
- External trigger
  A recording start can be triggered externally via a separate binary input. Recording is limited to 10 s and is performed for as long as a voltage is applied to this input. The duration of the recording and the pre- and post-faults can be parameterized. Smart sequence control monitors the trigger conditions during recording. If retriggering is permitted and the maximum fault recording length is reached, a dynamic fault recording length is reached. For external triggering, time synchronization of all SIMEAS R devices in the system is required to ensure the fault records have the same time reference.

Sequence control and trigger inhibit

The sequence control prevents overflow of the memory due to pending or cyclically repeated triggering. It also controls the variable recording times, enabling (for example) correct recording of sequential faults in the power system without recording being interrupted. The maximum recording time T_{max} is activated from the time of triggering and limits recording if the trigger criterion does not return to normal within time T_{max}.

The minimum recording time T_{min} is activated after return to normal of the trigger criterion from the active state. This ensures a minimum length of fault recording.

The trigger inhibit suppresses intermittent trigger conditions. It is activated as soon as a trigger criterion is fulfilled. Retriggering is prevented for as long as the trigger inhibit time is running. That means if the trigger criterion again changes from the passive to the active state, no retriggering occurs for as long as the trigger inhibit time is active. If a trigger criterion is fulfilled within the trigger inhibit time, the trigger inhibit time is restarted. If retriggering occurs after the trigger inhibit time has elapsed and before T_{max} has elapsed, recording continues. The T_{max}, T_{min} and trigger inhibit time parameters are set separately for each analog and binary channel.

Functions

Power and frequency recorder

The frequency and power recorder calculates and stores the active and reactive power and the power factor plus the frequency (P, Q, PF ($\cos\varphi$) and f). This function is used, for example, to record the load conditions before, during and after a fault in a power plant. Power swings in the power system and the frequency curve over a long time can be recorded.

One special application is recording of the properties of primary control in a power plant. For example, if a power plant unit is shut down at another location in a grid, the frequency of the power system will drop. This causes a considerable change in the power output of the power plant in which recording is taking place. Because all channels are recorded simultaneously, the user can establish a power balance, e.g. at the infeed points in substations.

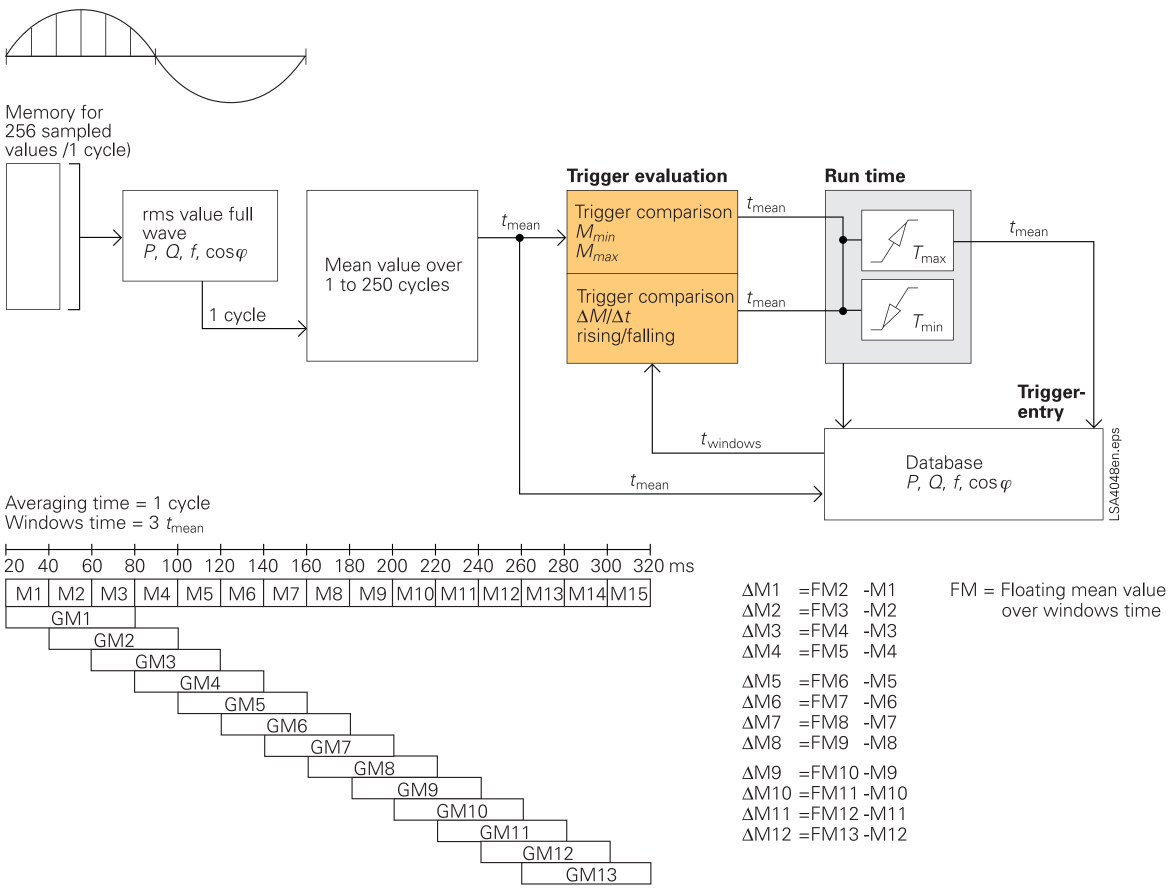


Fig. 13/112
Block diagram of the power and frequency recorder

Functions

Recording principle

The variables active power, reactive power, power factor and frequency (P, Q, PF ($\cos\varphi$) and f) are continuously calculated at intervals of one system cycle and stored in a buffer. If the parameter “averaging time” is set to “1", the calculation interval of the frequency and power recorder is one system cycle. The values in the fault recording therefore correspond to the values in the buffer. Other settings of the ”averaging time" parameter can reduce the recorder’s calculation interval. For example, if the “averaging time” parameter is set to “4", a mean value is formed over the 4 values of the variables (P, Q, PF ($\cos\varphi$), f) last calculated and written to the buffer after 4 system cycles have elapsed. This means that the calculation interval of the fault recording is 4 system cycles. The ”averaging time" parameter can be set in the range 1 to 250. The number of calculated values before the trigger point (pre-fault) can be selected in the range of 0 to 500.

The system frequency is measured via a voltage channel if the unit is equipped with an appropriate module (VDAU, VCDAU); if not, the frequency is measured via a current channel of a CDAU by automatic determination of the current signal with the highest amplitude and the lowest harmonic distortion.

Measured variables in a wye connection

If the recorder is in a “wye connection”, the powers and PF ($\cos\varphi$) are measured for each phase: $P1$, $P2$, $P3$, $P4$; Q1, Q2, Q3, Q4, PF 1, PF 2, PF 3, PF 4.

Measured variables in a delta connection

If the recorder is in a “delta connection”, the powers and PF ($\cos\varphi$) for the entire system are measured: P Q, PF ($\cos\varphi$).

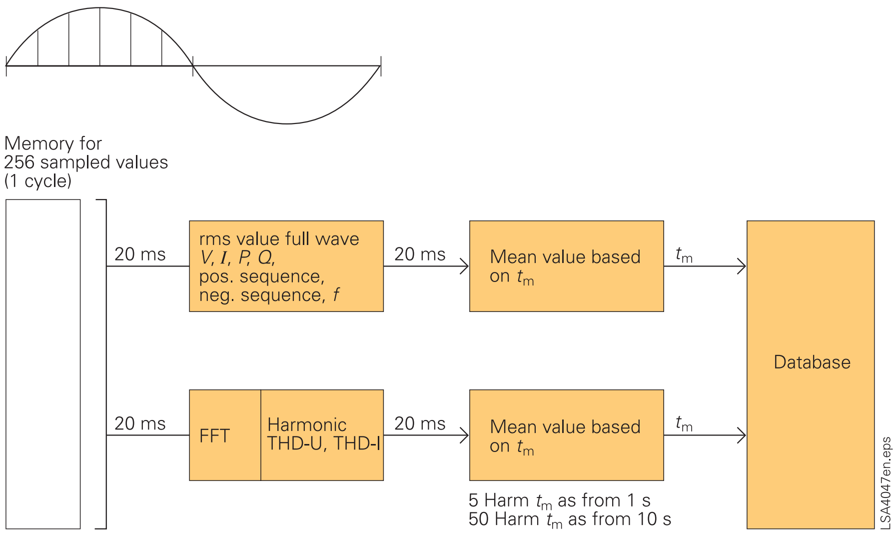


Fig. 13/113
Digital recorder function

Coupled CDAU functions

If both VCDAUs and CDAUs are used in a unit, the current channels of the CDAUs can be assigned to the voltages of a VCDAU. That way, the active and reactive powers can be calculated across DAUs. One typical application for this is monitoring the power of several feeders on a busbar.

The “coupled CDAU” feature requires external time synchronization.

The “frequency and power recorder” function uses similar trigger conditions to those for the “dynamic fault recorder for analog and binary channels” function. Here is a description of these functions:

- Triggering on the time value of the frequency or power (min./max. trigger)
  Triggering on the time value of the active power P, reactive power Q, frequency f, or power factor ($\cos\varphi$) is especially relevant, for example, if limit violations of these variables are being examined in a power plant. Triggering is detected if the measured variable exceeds the parameterized maximum or falls below the minimum.
- Triggering on a frequency or power change (dM/dt trigger)
  That means triggering on a positive or negative change of variables P, Q, or f. For this purpose, the change of the trigger variable in a parameterizable time interval is calculated and compared with the set limit. Triggering on values P, Q, or f is independent.
- Triggering via front panel (manual trigger)
  This function is especially useful for commissioning work, for example, to check the current direction of power flow or the power factor.
- PC triggering
  This triggering is started from the PC via the OSCOP P program.
- Network trigger
  The same principle applies as for an analog fault recorder. The “power and frequency recorder” function uses a separate trigger channel.

13

Functions

Power quality recorder and mean value recorder

The mean value recorder and power quality recorder functions store the signals continuously. The averaging time for the groups listed below can be freely parameterized in the range of 10 s to one hour. The following electrical quantities are measured, stored and displayed in the evaluation program:

– Voltage and current
– Active and reactive power
– Frequency, positive and negative sequence system
– Weighted and unweighted THD
– Current and voltage harmonic
– Process variables
– Voltage dips
– Flicker

With this function it is possible to monitor a substation or part of a substation (e.g. feeder) continuously and to evaluate its power quality. The measurement is used for monitoring the rms current progression as well as the active and reactive power. This enables the energy requirement of a feeder to be averaged over a long period. Moreover, an analysis of the rms voltage, the current harmonic progression, the THD, the progression of voltage dips and flicker effects (P_{st} and P_{lt} value) provides information about the quality of the power supply on a feeder. Existing fault sources can thus be located and countermeasures taken.

Event recorder

With the independent "event recorder" function, SIMEAS R continuously records the status of the binary inputs and stores them in an event memory. This permits analysis of the state changes of the binary inputs over a long time, for example, several months. This is relevant, for example, for examining faults that occur on switching.

The described independent recording functions "analog and binary recorder, frequency and power recorder, mean value and power quality recorder and event recorder" can run in parallel depending on the parameter settings.

Bulk storage

SIMEAS R features a bulk storage in flash technology to ensure the required high degree of reliability. During commissioning, it is possible to allocate separate areas to the various recorder functions, depending on the importance of the individual functions for the application. A memory allocation for a typical application could look like this:

a) Analog and binary recorder	200 MB
b) Frequency and power recorder	50 MB
c) Mean value and power quality recorder	100 MB
d) Event recorder	50 MB
e) Operating system and firmware	100 MB
Total	500 MB

The unit automatically reserves the memory range required for the operating system and firmware. Each memory range for recordings (a to d) is organized as a "circulating memory". As soon as a memory range is 90 % full after several recordings, the procedure is as follows: the "latest fault record" is written to memory first, then the oldest recordings are deleted until the free capacity in this range reaches 80 % of the allotted memory size.

Data compression

Even if you are using fast modem cards or a LAN/WAN connection, data compression is essential in a fault recorder to achieve:

– Efficient use of the device's internal bulk storage as a distributed data archive
– Fast transmission of the fault recordings to a DAKON or an evaluation PC to enable a fault analysis to be performed immediately after the fault
– Acceptable transmission times when using slow transmission media, e.g. an analog modem
– Coping with LAN/WAN "bottlenecks", which are particularly frequent in large-scale networks.

Example:

The data volume of a typical analog fault record with a duration of 2 s (100 system cycles at 50 Hz) with 4 DAUs (VCDAU, CDAU, or VDAU) and therefore 32 analog channels (without taking account of the 64 binary channels) without data compression is:

S = 32 x 256 x100 x 2 = 1,638,400 byte = 1.6384 MB

32 = number of analog channels

256 = sampled values per system cycle

100 = number of system cycles (100 x 20ms = 2 s at a system frequency of 50 Hz

2 = number of bytes per analog value

The data compression function of the SIMEAS R, which was specially developed for system faults, typically reduces this data volume, measured in many practical test cases, to 5 to 15 % (80 to 240 kB) of the theoretically calculated data volume.

Functions

Time synchronization

Time synchronization is achieved via a special input of the processor module to which a synchronization box (7KE6000-8HA*) is connected externally. Depending on implementation, the synchronization box can pick up the time signal from various receiver types, for example, via a GPS, DCF77 or IRIG-B. Synchronization with a GPS signal is the usual method. This requires special receivers that generally output a modulated telegram (DCF77, IRIG-B). This time telegram is passed on to the synchronization box. (In Germany and neighboring countries the DCF77 signal can be received directly. In this special case, the synchronization box can be connected to a DCF77 receiver with an integrated ferrite antenna.)

When configuring a fault recorder system, it is important to ensure that the right synchronization box is ordered for the receiver type. It decodes the receiver signal and sends a time telegram to the SIMEAS R with an internal protocol.

Independently of this synchronization, it is also possible to synchronize with a minute pulse via a binary input. This feature can be used to reset the second hand of the SIMEAS R's internal clock to zero on each pulse.

If external synchronization fails, all the data acquisition units (DAUs) of a recorder are synchronized by the internal clock. The time is adjusted automatically on recovery of the synchronization telegram. If two or more recorders are used at a single mounting location, the signal from the synchronization box is wired to the control input of the various recorders in parallel.

If the synchronization signal has to be distributed via optical cables due to a substantial distance between the various SIMEAS R recorders, the following additional components are required:

- Sync FO distributor: converts the 24-V signal of the synchronization box to 8 FO outputs (7KE6000-8AH/8AJ).
- Sync transceiver: converts the FO signal to 24 V (7KE6000-8AK/8AL).

Communication interfaces and components

SIMEAS R features the following communication interfaces:

- COM-S interface
  This RS232 interface on the front panel is for direct communication with an evaluation PC. This interface can be used to parameterize and test the recorder during commissioning. It has fixed communication parameters.
- COM1 interface
  This serial interface (RS232) is located on the rear of the recorder. This interface enables the recorder to communicate via an external analog or ISDN modem. The recorder can then be connected to a telephone network, but a direct modem-to-modem connection is also possible. The communication parameters of this interface can be set.
- PCMCIA interface for an analog modem
  The recorder has a PCMCIA slot for an analog modem for connection to an analog telephone network.
- Ethernet interface
  This integrated interface is used to connect the recorder to a LAN (local area network) IEEE 802.3 (10 Mbps Ethernet) with the TCP/IP protocol. (Please note that recorders delivered up to about February 2003 have a PCMCIA slot for an Ethernet card at the rear).
- Ethernet structure
  The network used to connect to an evaluation PC or a DAKON has star topology. One or more connection nodes (hubs) can be used. To improve the reliability of communication channels, optical cables can be used for the network. The following components can be used to set up an optical network:

– Transceiver
  (7KE6000-8AF/8AG)
  Converter from 10BASE-T ports with copper cable to 10BASE-FL with optical cable. The unit has an FO and a 10BASE-T network port. Housing: DIN rail mounting.

– Multiport repeater, or hub
  (7KE6000-8AD/8AE)
  This hub enables connection to two or more Ethernet cable segments. The unit has one FO and six 10BASE-T network ports. Housing: DIN rail mounting.

Functions

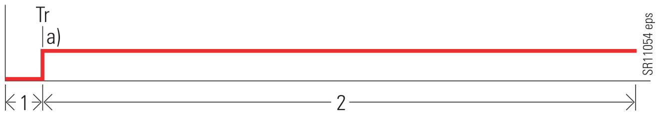
Examples of intelligent sequence control:

The examples are represented in the form of binary contacts. The intelligent sequence control can be applied to binary and analog inputs.

Example of T_{max} with state trigger

a) The state change is detected and the recording time T_{max} is started. If this state is maintained, the recording time T_{max} expires.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Trigger cause = binary



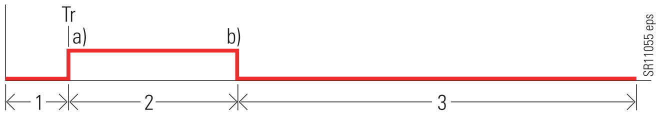
1 > Pre-fault = 100 ms, 2 > run time T_{max} = 1 s,
length of recording including pre-fault = 1100 ms

Examples of T_{min} with state trigger

a) The state change is detected and the recording time T_{max} is started.

b) If this state is not maintained, the recording time T_{min} expires, however, the time T_{max} is not exceeded.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Trigger cause = binary

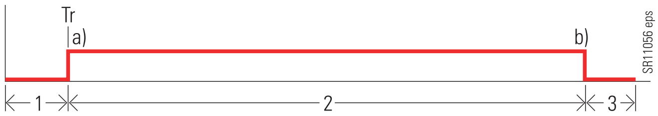


1 > Pre-fault = 100 ms, 2 > assumed 300 ms, 3 > run time T_{min} = 200 ms,
length of recording including pre-fault = 600 ms

a) The state change is detected and the recording time T_{max} is started.

b) If this state is not maintained, the recording time T_{min} expires, however, the time T_{max} is not exceeded.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Trigger cause = binary

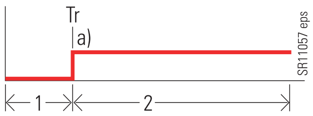


1 > Pre-fault = 100 ms, 2 > assumed 900 ms, 3 > run time T_{min} = 100 ms,
(limited by T_{max}), length of recording including pre-fault = 1100 ms

Example of T_{edge} with edge trigger

a) The state change is detected and the recording time T_{edge} is started. If the state changes on an input that was configured for an edge trigger, the recording time T_{edge} always expires.

Edge = 300 ms
Pre-fault = 100 ms
Trigger cause = binary



1 > Pre-fault = 100 ms, 2 > run time T_{edge} = 300 ms,
length of recording including pre-fault = 300 ms

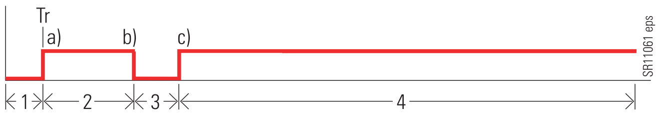
Examples of the inhibit time

a) The state change is detected and the recording time T_{max} and the inhibit time are started.

b) If this state is not maintained, the recording time T_{min} is started.

c) At this time, a new state change is detected and the recording time T_{max} and the inhibit time are restarted.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Inhibit time = 200 ms
Trigger cause = MIN



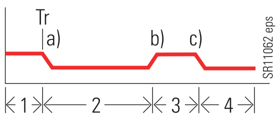
1 > Pre-fault = 100 ms, 2 > assumed 200 ms, 3 > assumed 100 ms,
4 > run time T_{max} = 1 s, length of recording including pre-fault = 1400 ms

a) A violation of the MIN limit is detected, and the recording time T_{max} and the inhibit time are started.

b) If this limit violation is not maintained, the recording time T_{min} is started.

c) At this time, the limit is violated but the recording time T_{max} is not restarted since the inhibit time is still active.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Inhibit time = 500 ms
Trigger cause = binary



1 > Pre-fault = 100 ms, 2 > assumed 200 ms, 3 > assumed 100 ms,
4 > run time derived from item b) T_{min} = 200 ms,
length of recording including pre-fault = 500 ms

13

Functions

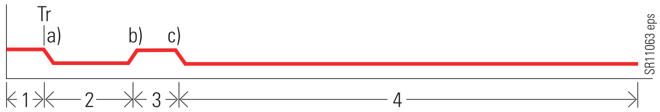
Example of the inhibit time

a) A violation of the MIN limit is detected and the recording time T_{max} and the inhibit time are started.

b) If this limit violation is not maintained, the recording time T_{min} is started.

c) At this time, the limit is violated, and the recording time T_{max} and the inhibit time are restarted.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Inhibit time = 200 ms
Trigger cause = MIN

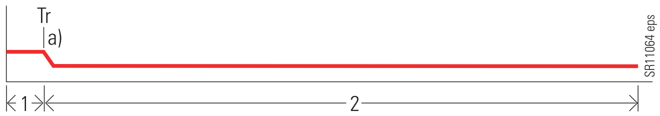


1 > Pre-fault = 100 ms, 2 > assumed 200 ms, 3 > assumed 100 ms, 4 > run time T_{max} = 1 s, length of recording including pre-fault = 1400 ms

Example of T_{max}

a) A violation of the MIN limit is detected and the recording time T_{max} is started.
If this limit violation is maintained, the recording time T_{max} expires.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Trigger cause = MIN



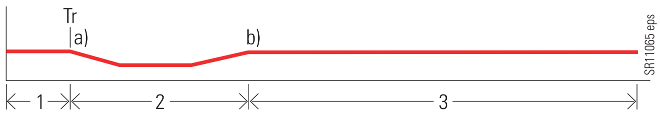
1 > Pre-fault = 100 ms, 2 > run time T_{max} = 1 s, length of recording including pre-fault = 1100 ms

Examples of T_{min}

a) A violation of the MIN limit is detected and the recording time T_{max} is started.

b) If this limit violation is maintained, the recording time T_{min} expires, however, the time T_{max} is not exceeded.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Trigger cause = MIN

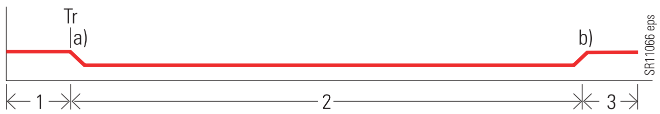


1 > Pre-fault = 100 ms, 2 > assumed 300 ms, 3 > run time T_{min} = 200 ms, length of recording including pre-fault = 600 ms

a) A violation of the MIN limit is detected and the recording time T_{max} is started.

b) If this limit violation is not maintained, the recording time T_{min} expires, however, the time T_{max} is not exceeded.

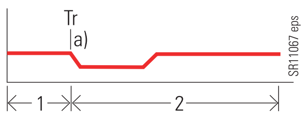
T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Trigger cause = MIN



1 > Pre-fault = 100 ms, 2 > assumed 900 ms, 3 > run time T_{min} = 100 ms, (limited by T_{max}), length of recording including pre-fault = 1100 ms

a) A lower limit violation of $\Delta m/\Delta t$ is detected and the recording time T_{min} is started. The recording time T_{min} is always started for a $\Delta m/\Delta t$ limit violation if no MIN or MAX trigger is simultaneously violated.

T_{min} = 200 ms
T_{max} = 1 s
Pre-fault = 100 ms
Inhibit time = 500 ms
Trigger cause = negative rate of change



1 > Pre-fault = 100 ms, 2 > run time T_{min} = 200 ms

13

Hardware

Housing

Two types of housing are available for SIMEAS R:

– 1/2 19-inch rack with 3 slots and
– 19-inch rack with 6 slots

The first slot is filled by the CPU module, the last slot of each rack by the PSU. The remaining slots can be filled with various data acquisition units (DAUs). The modules are slotted into the rack vertically and the terminals are located at the rear of the rack.

Central processor

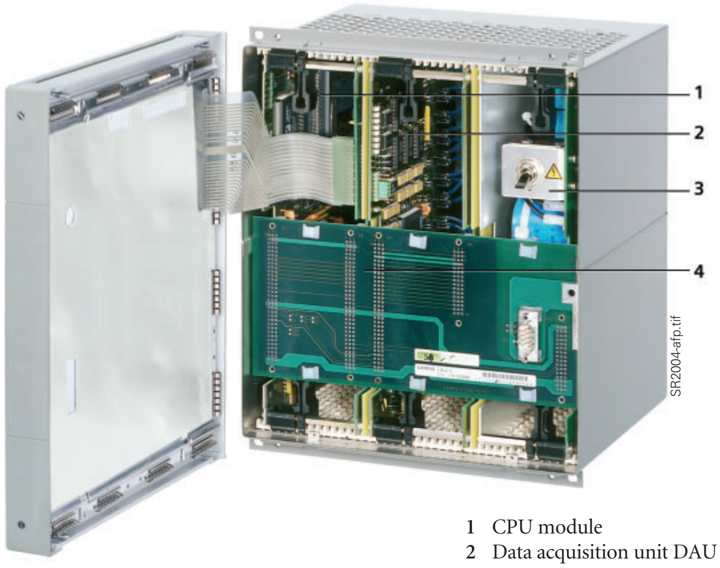
The central processor coordinates the data acquisition units, communication via the interfaces, and manages the database for the various fault records and mean values. It also monitors the entire hardware.

Power supply

The power supply is drawn from two different units (PSUs), depending on the supply voltage:

– 24 V - 60 V DC
– 110 V - 250 V DC and 115 - 230 V AC

In the event of a sudden power failure, the recorder continues to function, drawing its power from a storage capacitor (for details such as duration, see "Technical Data"). This allows time for a controlled reset if the power supply fails during operation. The PSU can optionally be equipped with a battery. The battery ensures operation for up to 10 minutes. The battery is loaded automatically and its charge state is monitored by an independent circuit. With a weekly automatic load test, the memory effect of the battery is reduced. Use of the battery is especially recommended if the recorder is powered from an AC source without PSU back-up.



1 CPU module
2 Data acquisition unit DAU
3 Power supply unit
4 Bus board

Fig. 13/114
Layout of a SIMEAS R

Fig. 13/115
Rear view

Data acquisition units (DAUs)

The following data acquisition units are available for the unit:

– VCDAU: 4 current / 4 voltage channels and 16 binary channels
– VDAU: 8 voltage channels and 16 binary channels
– CDAU: 8 current channels and 16 binary channels
– DDAU: 8 channels for process variables and 16 binary channels
– BDAU: 32 binary channels

The AC inputs of the DAUs are rated and calibrated for system frequencies 50 Hz / 60 Hz / 16.7 Hz. The sampling frequency of the analog channels is $f_A = 256 \times f_N$.

f_A = sampling frequency
f_N = rated frequency of the system voltage.

13

Hardware

Sampling rates resulting from rated frequency settings

Rated frequency f_N	Sampling rate
50 Hz	12.8 kHz
60 Hz	15.3 kHz
16.7 Hz	4.3 kHz

Analog-to-digital converters

Each analog channel has a 16-bit analog-to-digital converter (ADC) with an integrated dynamic anti-aliasing filter. This obviates use of an external anti-aliasing filter. The anti-aliasing filter automatically adapts to the network environment because the recorder sampling rate and therefore the sampling rate of the ADC are set with the parameter for the rated system frequency.

Dynamics of the current channels

The CDAU comprises eight (and the VCDAU four) current channels. Each current channel has two independent ADCs. The first ADC is connected to an inductive current transformer (CT) that is optimized for the current range of 0 to 7 A (rms value) and dimensioned for very high precision. If a higher current is measured, the recorder automatically switches over to the input of the second CT. This CT is connected to a hall generator that measures the same current as the inductive transformer but is optimized for the 0 to 600 A range (high dynamics). Because the hall generator also transmits DC, its frequency range does not have a lower limit. Use of two different transformer principles ensures that the recorder measures very accurately in the nominal range of the line current and, in the event of a fault, records current curves with high amplitude and sustained DC component without any loss of information.

Current terminals

If a CDAU or VCDAU is removed from the rack, the current terminals are automatically shorted out to avoid damaging the connected CT.

Channels for process signals

The sampling rate of a DDAU is a fixed 10 kHz, if other DAU types are used in the recorder. However, if a recorder contains only DDAUs, sampling rates of 10 Hz / 100 Hz / 1 kHz / 10 kHz can be parameterized.

A low sampling rate setting is recommended for monitoring slowly varying process variables (to keep the recorded data volume manageable). These channels can be connected to ± 10 V, ± 1 V or ± 20 mA, depending on the type.

Configuration notes

The PCMCIA memory and communication cards used for the modem or Ethernet in PCCARD technology are constantly undergoing further development. Because they are used in substations, where CE markings are prescribed, only cards approved by Siemens may be used in the system. In particular, the system noise immunity stipulated by the applicable IEC regulations and the high ambient temperature range necessitate special cards. The planning department should be consulted about selecting the correct PCs and correctly setting up the overall system.

Modes

The SIMEAS R has three operating modes:

Normal mode
In normal mode all functions are active.

Blocked mode
In blocked mode, the recording functions “dynamic recorder for analog and binary channels” and “power and frequency recorder” are inactive, i.e. no fault records are recorded. If this mode is selected, only the functions “mean value and power quality recorder” and “event recorder” are active. The mode is used, for example, to test equipment connection during commissioning.

Test mode
In test mode, all functions are active but recorded events are entered with “test” as their cause. The “event recorded” alarm relay does not pick up. “Test mode” is used to check the functionality of the SIMEAS R. The different modes can be selected on the keyboard. Remote control via OSCOP P is possible at any time.

Hardware

LEDs on the front panel of the recorder
The front panel of the recorder contains 8 red and 8 green parameterizable LEDs assigned as follows:

8 green LEDs

- Recorder in operation
- Operating voltage OK
- Battery capacity OK
- Event recorded
- Data transmission to the PC
- Circulating memory active
- Two further LEDs freely programmable

8 red LEDs

- Fault DAU(s)
- Fault printer
- Fault time synchronization
- Fault fine synchronization
- Fault data memory
- PC not accessible
- Temperature ≤ 5 °C
- Temperature ≥ 55 °C,

and 5 LEDs permanently assigned to the control buttons listed below

Control buttons
The recorder has the following control buttons that are located on the front panel:

- Acknowledge group alarm
- Normal mode
- Blocked mode
- Test mode
- Manual trigger

Control inputs
There are four contact inputs at the rear of the recorder:

- Acknowledge group alarm
- System reset
- External start
- Time synchronization

Alarm outputs
The recorder has four alarm outputs. The first is permanently connected to the processor watchdog. The other three can be freely programmed and are pre-assigned as follows:

- Watchdog
- Ready to run
- Event being recorded
- Group alarm

Group alarm
– Fault DAU(s)
– Fault printer
– Fault synchronization
– Fault data memory

LSP2824.tif

Fig. 13/116
LEDs and control buttons

13

Technical data

Mechanical design	
1/2 19" version	
Dimensions (W x H x D)	223 x 266 x 300 mm
Number of slots	3
Slot 1 - CPU	
PCCARD Slot	Slot 0 Type I and II Slot 1 Type I to III
Slot 2 DAU	See “Analog and binary in- and outputs”
Slot 3 Power supply unit	
19" version	
Dimensions (W x H x D)	445 x 266 x 300 mm
Number of slots	6
Slot 1 - CPU	Approx 1.5 mA/input
PCCARD Slot	Slot 0 Type I and II Slot 1 Type I to III
Slot 2 - 5 DAU	See “Analog and binary in- and outputs”
Slot 6 Power supply	

Auxiliary voltage		
Low-voltage version		
DC voltage		
Rated auxiliary DC voltage V_{aux}	24/28/60 V DC	
Permissible voltage ranges	19.2 to 72 V DC	
High-voltage version		
DC voltage		
Rated auxiliary DC voltage V_{aux}	110/125/220/250 V DC	
Permissible voltage ranges	88 to 300 V DC	
AC voltage 50/60 Hz		
Rated auxiliary DC voltage V_{aux}	115/230 V AC	
Permissible voltage ranges	92 to 276 V AC	
Voltage stability without back-up battery		
Bridging time	Measured times Central unit ZE8/16	ZE32/64
for V_{aux} = 24 V DC	≥ 400 ms	≥ 150 ms
for V_{aux} = 60 V DC	≥ 450 ms	≥ 170 ms
for V_{aux} = 110 V DC	≥ 500 ms	≥ 180 ms
for V_{aux} = 250 V DC	≥ 700 ms	≥ 200 ms
for V_{aux} = 115 V AC	≥ 500 ms	≥ 200 ms
for V_{aux} = 230 V AC	≥ 800 ms	≥ 348 ms
Optionally with back-up battery	Power failure bridging time up to 10 min with all functions operating	
Power consumption		
1/2 19" version 8 analog / 16 binary channels	24 to 60 V DC 110 to 250 V DC 115 to 230 V AC	20 W 18 W 30 VA
19" version 32 analog / 64 binary channels	24 to 60 V DC 110 to 250 V DC 115 to 230 V AC	45 W 40 W 70 VA

Analog and binary inputs and outputs			
Slot 2 (1/2 19" version)	To be equipped according to table “Equipping version”		
Slot 2 to 5 (19" version)	To be equipped according to table “Equipping version”		
Equipping versions			
VCDAU	8 analog (4 current / 4 voltage) and 16 binary channels		
CDAU	8 analog (8 current) and 16 binary channels		
VDAU	8 analog (8 voltage) and 16 binary channels		
BDAU	32 binary channels		
DDAU	8 analog (8 current ± 20 mA or 8 voltage ± 1 V or ± 10 V) and 16 binary channels		
VCDAU, CDAU und VDAU	Sampling frequency	Rated frequency	Frequency range
	4.3 kHz	16.7 Hz	12 to 20 Hz
	12.8 kHz	50 Hz	40 to 60 Hz
	15.36 kHz	60 Hz	50 to 70 Hz
	64 times oversampling		

Voltage input (VDAU or VCDAU)	
Measuring range 1	1.5 to 200 V_{rms}
Impedance	>100 kΩ
Resolution	15 mV
Overvoltage	Max. 300 V_{rms} for 5 s
Accuracy (at 23 °C 1 °C and rated frequency)	Class 0.3 ± 0.25 % of measured value ± 30 mV
Frequency response	3 to 5500 Hz (5 %)
Number of analog-digital converters per channel	1
Measuring range 2	3 to 400 V_{rms}
Impedance	> 200 kΩ
Resolution	30 mV
Overvoltage	Max. 600 V_{rms} for 5 s
Accuracy (at 23 °C 1 °C and rated frequency)	Class 0.3 ± 0.25 % of measured value ± 30 mV
Frequency response	3 to 5500 Hz (5 %)
Number of analog-digital converters per channel	
Voltage channel	1
Current channel	2

Technical data

Analog and binary inputs and outputs *(cont´d)*	
Current input (CDAU or VCDAU)	
Dynamic AD and converter switching	
Measuring range	5 mA to 400 A_{rms}
Accuracy range	5 mA to 7 A_{rms}
Resolution	0.5 mA
(at 23 °C ± 1 °C and rated frequency)	Class 0.5 ± 0.5 % of measured ± 0.5 mA
Frequency response	3 to 5500 Hz (5 %)
Range	> 7 A_{rms} to 200 A_{rms}
Resolution	30 mA
(at 23 °C ± 1 °C and rated frequency)	Class 1.5 ± 1.5 % of measured value ± 30 mA
Frequency response	0 to 5500 Hz (5 %)
Range	> 200 A_{rms} to 400 A_{rms}
Resolution	30 mA
(at 23 °C ± 1 °C and rated frequency)	Class 3.5 ± 3.5 % of measured value
Frequency response	0 to 5500 Hz (5 %)
Continuous	20 A
Overload	100 A, 30 s 500 A, 1s 1200 A, half-wave
Recording	200 A, plus 100 % displacement
Burden	< 0.1 VA
DC inputs (DDAU)	
Input range (depending on the Order No.)	± 20 mA (50 Ω) ± 1 V / ± 10 V (> 40 kΩ / > 400 kΩ)
Accuracy (at 23 °C ± 1 °C	Class 0.5
Range 1 V	± 0.5 % measured value ± 1 mV
Range 10 V	± 0.5 % measured value ± 10 mV
Range 20 mA	± 0.5 % measured value ± 20 µA
Sampling frequency	10 Hz, 100 Hz, 1 kHz, 10 kHz per module (parameterizable) (if used together with a VCDAU, CDAU, or VDAU, the DC channels are recorded in parallel. Only a sampling rate of 10 kHz per channel is permitted.) Processing of higher DC voltages via isolation amplifier (e.g. SIMEAS T)

Analog and binary inputs and outputs *(cont´d)*			
Binary inputs (BDAU, VCDAU, DDAU, CDAU und VDAU)			
Sampling frequency	2 kHz		
Principle of storage	Only status changes are stored with real time and a resolution of 1 ms		
Storage capacity	250 status changes per 16 inputs, within 1 s, total storage capacity depends on the parameter setting (typically approx. 100,000 status changes)		
Voltage ranges of control inputs according to components installed	Input voltage V	L-level V	H-level V
	24	≤ 7	≥ 18
	48 to 60	≤ 14	≥ 36
	110 to 125	≤ 28	≥ 75
	220 to 250	≤ 56	≥ 165
	Input current 1 mA		
	Input voltage V	Overload V	
	24	28.8	
	48 to 60	72	
	110 to 125	150	
	220 to 250	300	

13

Technical data

Binary inputs and outputs			
Control inputs	4 inputs		
Input 1	Input for time synchronization for connection to the synchro-box or a station clock with minute pulse 24 to 60 V, filter time > 2 µs > 110 V, filter time < 5 µs		
Input 2	External start, filter time 50 ms		
Input 3	External reset filter time 50 ms		
Input 4	External group alarm Filter time 50 ms		
Voltage ranges of control inputs according to components installed	Input voltage V	L-level V	H-level V
	24	≤ 7	≥ 18
	48 to 60	≤ 14	≥ 36
	110 to 125	≤ 28	≥ 75
	220 to 250	≤ 56	≥ 165
	Input current 1 mA		
	Input voltage V	Input 1 Overload V	Input 2 to 4 Overload V
	24	28.8	28.8
	48 to 60	72	72
	110 to 125	150	150
	220 to 250	300	300
Signal outputs			
	4 signal outputs with isolated main contact, signal output 1 hard-wired to watchdog, 3 signals outputs freely allocatable.		
Switching capacity	MAKE 30 W/VA BREAK 20 VA 30 W resistive 25 W for L/R ≤ 50 ms		
Switching voltage	250 V		
Permissible current	1 A continuous		
Allocation of the signal outputs and status of LEDs	SIMEAS R ready for operation Operating voltage OK Normal mode Test mode Locked mode Transmission SIMEAS R - PC active Recording event DAU fault Printer fault Time synchronization error Computer not available Data memory fault Data memory full Cyclic storage active Battery capacity OK Temperature monitoring < –5 °C Temperature monitoring > +55 °C Fine synchronization error Group alarm Relay 1 - not allocatable; watchdog Relay 2 - not allocatable Relay 3 - not allocatable Relay 4 - not allocatable		

Communication interfaces	
Slot 1 - CPU	
LPT 1	Printer interface, Centronics, for connection of a laser printer (Emulation Postscript level 2)
COM 2/COM S	RS232 serial interface, on front side for connection of a PC, 19.2 kBd
COM 1	RS232 serial interface, on rear for connection of e.g. an additional modem, 300 Bd to 57.6 Bd or an external ISDN terminal adapter
Ethernet	Compatible acc. to IEEE 802.3 Software TCP/IP Twisted pair (10BaseT), RJ45 connector
Slot 0 data transmission	
Modem	Transmission rate up to 56 kBps Dialing method audio and pulse CCIT V.21, V.22, V.22 to V.23, V.32, V.32 to V.34, V.90 Certified in all European countries

Climatic stress	
Temperatures	
Transport and storage	–25 °C to +70 °C
Operation for cubicle/panel flush-mounting	–5 °C to +55 °C (condensation not permissible)
for panel surface-mounting	0 °C to +40 °C
Humidity	95 % without condensation

13

Selection and ordering data

Description	Order No.
SIMEAS R central unit ZE8/16 with integrated Ethernet port	*7KE6000-0□□□□ - □□□□*
With one slot for data acquisition unit (DAU); ½ x 19" rack	
Housing	
For panel flush mounting (perforated housing)	D
For surface mounting (perforated housing)	E
For 19" assembly (perforated housing)	F
Measurement at	
16.7 Hz network	C
50 Hz network	D
60 Hz network	E
Remote data transmission to DAKON or evaluation PC in addition to the integrated Ethernet port	
(Cables must be ordered separately)	
Usage of COM1 or COM2 or Ethernet/Standard	4
External ISDN modem	5
Analog PCMCIA modem	6
Terminals	
Standard	1
US design (not possible with surface mounting housing)	2
Signal voltages of the CPU and the binary inputs	
24 V DC	1
48 - 60 V DC	2
110 - 125 V DC	3
220 - 250 V DC	4
48 - 60 V DC, control input 1 24 V DC[1)]	5
110 - 125 V DC, control input 1 24 V DC[1)]	6
220 - 250 V DC, control input 1 24 V DC[1)]	7
Data acquisition unit DAU	
VDAU (8 *U* / 16 binary inputs)	A
CDAU (8 ***I*** / 16 binary inputs)	B
VCDAU (4 *U* / 4 ***I*** / 16 binary inputs)	C
BDAU (32 binary inputs)	D
DDAU 20 mA	F
DDAU 1 V	G
DDAU 10 V	H
Auxiliary power	
24 to 60 V DC without battery	G
24 to 60 V DC with battery	H
50/60 Hz, 115/230 V AC or 110 V to 250 V DC without battery	J
50/60 Hz, 115/230 V AC or 110 V to 250 V DC with battery	K
Manual	
German	1
English	2
French	3
Spanish	4
Italian	5
Portuguese	7

1) For connecting a synchronization unit 7KE6000-8HA.. the control input 1 of the CPU has to be dimensioned for 24 V DC.

Selection and ordering data

Description	Order No.
SIMEAS R central unit ZE32/64 with integrated Ethernet port	*7KE6000-1□□□□ - □□□□*
With four (4) slots for data acquisition units (DAUs); 19" rack	
Housing	
For panel flush mounting (perforated housing)	D
For surface mounting (perforated housing)[1]	E
For 19" assembly (perforated housing)	F
Measurement at	
16.7 Hz network	C
50 Hz network	D
60 Hz network	E
Remote data transmission to DAKON or evaluation PC in addition to the integrated Ethernet port	
(Cables must be ordered separately)	
Usage of COM1 or COM2 or Ethernet	4
External ISDN modem	5
Analog PCMCIA modem	6
Terminals	
Standard	1
US design (not possible with surface mounting housing)	2
Signal voltages of the CPU and the binary inputs for units without free assembly of the DAUs	
24 V DC	1
48 - 60 V DC	2
110 - 125 V DC	3
220 - 250 V DC	4
48 - 60 V DC, control input 1 24 V DC[2]	5
110 - 125 V DC, control input 1 24 V DC[2]	6
220 - 250 V DC, control input 1 24 V DC[2]	7
Data acquisition unit DAU	
Note: The fitting of the DAUs is from left to right	
VCDAU; 2 units (8 *U* / 8 *I* /32 binary inputs)	A
VCDAU; 4 units (16 *U* / 16 *I* / 64 binary inputs)	B
VCDAU; 1 unit (4 *U* / 4 *I* / 16 binary inputs) and CDAU; 3 units (24 *I* / 48 binary inputs)	C
Data aquisition units (DAUs) for free assembly	D

Note:
You need to select the required DAU units according to the 7KE6000-4** instructions.
By these instructions, the type of the data acquisition units and the binary inputs will be defined.

Description	Order No.
Auxiliary power	
24 to 60 V DC without battery	G
24 to 60 V DC with battery	H
50/60 Hz, 115/230 V AC or 110 V to 250 V DC without battery	J
50/60 Hz, 115/230 V AC or 110 V to 250 V DC with battery	K
Manual	
German	1
English	2
French	3
Spanish	4
Italian	5
Portuguese	7

1) The number of the possible measuring channels of surface mounting must be evaluated by the factory.

2) For connecting a synchronization unit 7KE6000-8HA..
the control input 1 of the CPU has to be dimensioned for 24 V DC.

13

Selection and ordering data

Description		Order No.
SIMEAS R assembly of the central unit ZE32/64[1)]		*7KE6000-4□□66 - 6□□0*
Slot 1		
VCDAU	to be equipped in the factory[2)]	J
CDAU	to be equipped in the factory[2)]	K
VDAU	to be equipped in the factory[2)]	L
BDAU	to be equipped in the factory[2)]	M
DDAU	to be equipped in the factory[2)]	N
–	not prepared / plate only	P
VCDAU	prepared for a VCDAU for future use	Q
CDAU	prepared for a CDAU for future use	R
VDAU	prepared for a VDAU for future use	S
BDAU	prepared for a BDAU for future use	T
DDAU	prepared for a DDAU for future use	U
Slot 2		
VCDAU	to be equipped in the factory[2)]	A
CDAU	to be equipped in the factory[2)]	B
VDAU	to be equipped in the factory[2)]	C
BDAU	to be equipped in the factory[2)]	D
DDAU	to be equipped in the factory[2)]	E
–	not prepared / plate only	F
VCDAU	prepared for a VCDAU for future use	G
CDAU	prepared for a CDAU for future use	H
VDAU	prepared for a VDAU for future use	J
BDAU	prepared for a BDAU for future use	K
DDAU	prepared for a DDAU for future use	L
Slot 3		
VCDAU	to be equipped in the factory[2)]	A
CDAU	to be equipped in the factory[2)]	B
VDAU	to be equipped in the factory[2)]	C
BDAU	to be equipped in the factory[2)]	D
DDAU	to be equipped in the factory[2)]	E
–	not prepared / plate only	F
VCDAU	prepared for a VCDAU for future use	G
CDAU	prepared for a CDAU for future use	H
VDAU	prepared for a VDAU for future use	J
BDAU	prepared for a BDAU for future use	K
DDAU	prepared for a DDAU for future use	L
Slot 4		
VCDAU	to be equipped in the factory[2)]	A
CDAU	to be equipped in the factory[2)]	B
VDAU	to be equipped in the factory[2)]	C
BDAU	to be equipped in the factory[2)]	D
DDAU	to be equipped in the factory[2)]	E
–	not prepared / plate only	F
VCDAU	prepared for a VCDAU for future use	G
CDAU	prepared for a CDAU for future use	H
VDAU	prepared for a VDAU for future use	J
BDAU	prepared for a BDAU for future use	K
DDAU	prepared for a DDAU for future use	L

1) Please apply only for free fitting. The central unit includes 4 slots for free fitting with data acquisition units (DAUs). Preparation of the slots with the corresponding terminals and fitting with DAUs.

2) Please specify and order the unit 7KE6000-2.

13

Selection and ordering data

Description	Order No.
SIMEAS R, data acquisition units for free fitting of the central unit ZE32/64 or as spare parts	*7KE6000 - 2□□□□*
VDAU (8 *U* / 16 binary inputs)	A
CDAU (8 *I* / 16 binary inputs)	B
VCDAU (4 *U* / 4 *I* / 16 binary inputs)	C
BDAU (32 binary inputs)	D
Signal voltages of the binary inputs	
24 V DC	A
48 to 60 V DC	B
110 to 125 V DC	C
220 to 250 V DC	D
Terminals	
Standard	1
US design	2
Without terminals as the central unit is already equipped with terminals	3
System frequency	
No frequency information in case of order number position 9 = *D*	0
16.7 Hz	1
50 Hz	2
60 Hz	3

SIMEAS R, acquisition units for free fitting or as spare parts	*7KE6000 - 2□□□□*
DDAU (8 DC / 16 binary inputs)	E
Terminals	
Standard	A
US design	B
Without terminals, as the central unit is already equipped with terminals	C
Analog channels	
20 mA	1
1 V	2
10 V	3
Signal voltages for binary inputs	
24 V	1
48 to 60 V DC	2
110 to 125 V DC	3
220 to 250 V DC	4

Selection and ordering data

Description	Order No.
SIMEAS R - Spare parts	
Spare flash memory for CPU-486 with firmware 2.1.xx[1)]	
PCMCIA Flash memory with PC card format and firmware 2.1.xx[1)] with standard parameterization	7KE6000-3HA
PCMCIA Flash memory card with PC card format and firmware 2.1.xx*) with customer-specific parameterization Further information on ordering of the customer-specific parameterization can be obtained at: http://www.powerquality.de	7KE6000-4HA
Spare flash memory for CPU-486 with firmware 2.3.xx[2)]	
PCMCIA Flash memory with PC card-format with pre-installed firmware 2.3.xx[2)] with additional functions „recording of flicker and voltage sags" with standard parameterization Valid only for units with RAM memory of 32 MB Further information on our Web site: http://www.powerquality.de	7KE6000-3HB
PCMCIA Flash memory with installed firmware 2.3.xx[2)] with additional functions „recording of flicker and voltage sags" with customer-specific parameterization Valid only for units with RAM memory of 32 MB Further information on our Web site: http://www.powerquality.de	7KE6000-4HB
512 MB Flash memory for ELAN CPU + firmware 3.0.xx	
IDE flash memory 2.5" and firmware 3.0.xx	
with standard parameterization	7KE6000-3HC1
with customer-specific parameterization	7KE6000-3HC2
Further information on our Web site: http://www.powerquality.de	

1) Current version of firmware 2.1

2) Current version of firmware 2.3

Selection and ordering data

Description	Order No.
SIMEAS R - Spare parts	
Central processor unit (ELAN-CPU)	*7KE6000 - 2L□□*
Mass storage and firmware	
With IDE-flash memory 2.5" format and current firmware with standard parameterization	*1*
With IDE-flash memory 2.5" format and current firmware with customer-specific parameterization	*2*
Further information on ordering of the customer-specific parameterization can be obtained at: http://www.powerquality.de	
Input signal voltage	
24 V DC	*A*
48 to 60 V DC	*B*
110 to 125 V DC	*C*
220 to 250 V DC	*D*
48 to 60 V DC, control input 1 DC 24 V (see note)	*E*
110 to 125 V DC, control input 1 DC 24 V (see note)	*F*
220 to 250 V DC, control input 1 DC 24 V (see note)	*G*
Note: The control input 1 of CPU has to be dimensioned for 24 V DC on connection of the 7KE6000-8HA** synchronization box.	
Power supply for central processor unit	*7KE6000-2G□*
24 to 60 V DC without battery	*G*
24 to 60 V with battery	*H*
50/60 Hz, 115/230 V AC or 110 to 250 V DC without battery	*J*
50/60 Hz, 115/230 V AC or 110 to 250 V DC with battery	*K*
Modems / Ethernet card *remote access server*	*7KE6000-2J□*
PCMCIA card Ethernet; IEEE 802.3; TCP/IP (for CPU-486)	*C*
Analog modem, external	*D*
Analog modem, external for rail mounting	*E*
ISDN modem, external	*F*
ISDN modem, external for rail mounting	*G*

Selection and ordering data

Description	Order No.
Synchronization unit [1]	*7KE6000 - 8HA☐☐*
In housing with snap-on attachment for 35 mm top-hat rail according to EN 50 022 with connection cable for ZE (central unit)	
Receiver/decoder module for synchronization (connection via BNC connector)	
DCF77 receiver (please order antenna 7KE6000-8AQ separately)	1
Decoder for DCF77 signal (to connect to a GPS receiver with DCF77 output signal f. example to a HOPF 6870 GPC receiver. This is the best choice for all applications worldwide)	2
Decoder for Meinberg or ZERA signal	3
Decoder for Patek - Philippe signal	4
Decoder for IRIG B signal (e.g. of GPS receiver)[2]	5
Decoder for telenorma signal	6
Decoder for demodulated IRIG B signal, TTL level	7
Decoder for demodulated DCF77 signal, open collector connection	8
Auxiliary power	
24 to 60 V DC	1
110 to 250 V DC or 115 to 230 V AC 50/60 Hz	2
Rugged switch RS1600	*7KE6000 - 8AP☐0 - ☐AB*
12 x 10BaseFL ports with ST connector 2 x 100BaseFX ports 2 x 10/100BaseFT ports with RJ45 connector	
Power supply	
24 V DC	0
48 V DC	1
88 - 300 V DC/85 - 264 V AC	2
FO option for 100BaseFX ports	
1300 nm, multi-mode, 2 km with SFF MTRJ connector	0
1310 nm, mono-mode, 15 km with SFF LC connector	1
Components for Ethernet communication	
HUB LV [3]	*7KE6000-8AD*
HUB HV [4]	*7KE6000-8AE*
Transceiver LV [3]	*7KE6000-8AF*
Transceiver HV [4]	*7KE6000-8AG*
Components for time synchronization	
Sync.-FO cable converter LV [3]	*7KE6000-8AH*
Sync.-FO cable converter HV [4]	*7KE6000-8AJ*
Sync. -transceiver LV [3]	*7KE6000-8AK*
Sync.-transceiver HV [4]	*7KE6000-8AL*

1) For connecting a synchronization unit 7KE6000-8HA.. the control input 1 of the CPU has to be dimensioned for 24 V DC.

2) The IRIG-B signal has the following disadvantages: the year is not indicated, there is no switchover for daylight saving time, there is no relative time (not orientated towards time zones). It is strongly recommended to use a GPS receiver with a DCF77 output. The DCF77 signal can then be adapted to the DCF77 signal for SIMEAS R and DAKON via a synchbox.

3) LV ≙ 24 - 60 V DC

4) HV ≙ 110 - 230 V DC/AC, 45 - 65 Hz

Selection and ordering data

Description	Order No.
DCF77 antenna	*7KE6000-8AQ*
With antenna cable, length 10 m	
Communication cable COM1 - to external modem	*7KE6000-8AC*
Modem side 25-pole / pin, length 10 m	
Communication cable COM1 to PC	*7KE6000-8B□*
Incl. adapter set	
COM1 or 2 - PC, length 10 m	*A*
COM1 or 2 - PC, length 5 m	*B*
Printer cable, Centronics	*7KE6000-8DA*
Length 3 m, ZE or PC - printer	
Ethernet patch cable with double shield (SFTP), LAN connector on both sides SIMEAS R ↔ HUB, HUB ↔ PC	
Length 0.5 m	*7KE6000-8GD00-0AA5*
Length 1 m	*7KE6000-8GD00-1AA0*
Length 2 m	*7KE6000-8GD00-2AA0*
Length 3 m	*7KE6000-8GD00-3AA0*
Length 5 m	*7KE6000-8GD00-5AA0*
Length 10 m	*7KE6000-8GD01-0AA0*
Length 15 m	*7KE6000-8GD01-5AA0*
Length 20 m	*7KE6000-8GD02-0AA0*
Ethernet patch cable with double shield (SFTP), cross-over connection, LAN connector on both sides HUB ↔ HUB, SIMEAS R ↔ PC	
Length 0.5 m	*7KE6000-8GE00-0AA5*
Length 1 m	*7KE6000-8GE00-1AA0*
Length 2 m	*7KE6000-8GE00-2AA0*
Length 3 m	*7KE6000-8GE00-3AA0*
Length 5 m	*7KE6000-8GE00-5AA0*
Length 10 m	*7KE6000-8GE01-0AA0*
Length 15 m	*7KE6000-8GE01-5AA0*
Length 20 m	*7KE6000-8GE02-0AA0*

Selection and ordering data

Description	Order No.	Order code
Connection cable for current inputs		
8-core flexible cable, 2.5 mm², for 4 current channels	*7KE6000 - 8GA00 - 0□□□ □□□*	
Please note: Minimum length 2 m		
Without pre-assembled cables	*A*	
With end sleeve ferrule	*B*	
With end sleeve ferrule on both sides	*C*	
Without core identification	*A*	
With core identification	*B*	
Connection cable for voltage inputs	*7KE6000-8GB00-0□□□ □□□*	
8-core flexible cable, 0.75 mm², for 4 voltage channels		
Please note: Minimum length 2 m		
Without pre-assembled cables	*A*	
With end sleeve ferrule on one side	*B*	
With end sleeve ferrule on both sides	*C*	
Without core identification	*A*	
With core identification	*B*	
Connection cable for binary inputs	*7KE6000-8GC00-0□□□ □□□*	
32-core flexible cable, 0.25 mm²		
Please note: Minimum length 2 m		
Without pre-assembled cables	*A*	
With end sleeve ferrule on one side	*B*	
With end sleeve ferrule on both sides	*C*	
Without core identification	*A*	
With core identification	*B*	
Cable length 2 m and longer		
2 m	*2*	
3 m	*3*	
4 m	*4*	
5 m	*5*	
6 m	*6*	
7 m	*7*	
8 m	*8*	
9 m	*9 R 1 A*	
Special length (please state length in plain text)	*9 R 1 Y*	

Description	Order No.
Manual	
for firmware version 3.xx	
English	*E50417-B1076-C209-A1*
German	*E50417-B1000-C209-A1*
French	*E50417-B1077-C209-A1*
Spanish	*E50417-B1078-C209-A1*
Italian	*E50417-B1072-C209-A1*
Portuguese	*E50417-B1079-C209-A1*
Training	
English	*9CA4030-0KE00-0BA4*
German	*9CA4030-0KD00-0BA4*

on SIMEAS R, DAKON and OSCOP P / SICARO PQ,
duration 2 days, will be held in our training center in Nuremberg

13

OSCOP P
Parameterization and Analysis Software for Power Quality

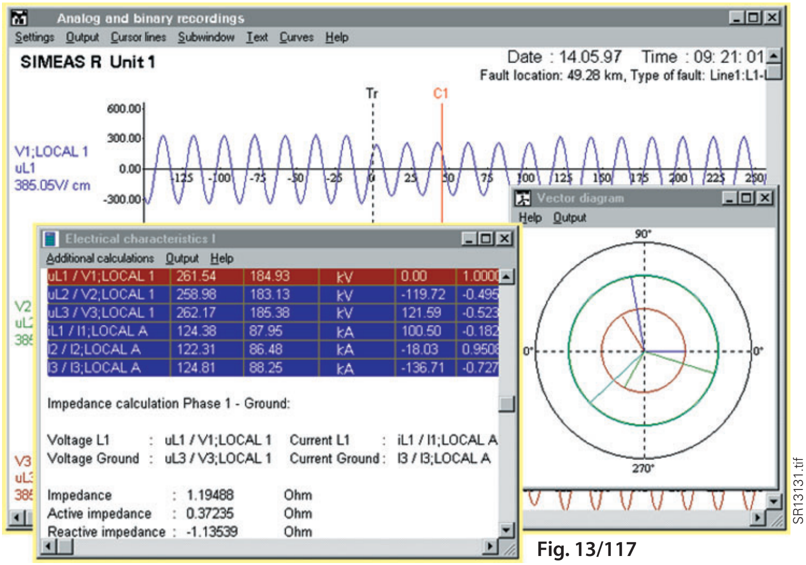


Fig. 13/117
OSCOP P, example of measurement by cursor with vector diagram

Description

The software OSCOP P is a program package for parameterization and automated remote transmission, archiving, evaluation files which have been recorded with a SIMEAS R digital fault and power quality recorder, OSCILLOSTORE P531 or with numerical protection relays using the IEC 60870-5-103 protocol. It incorporates extensive functions and computation algorithms for manual or automated analysis and evaluation of events in a power system. With OSCOP P and SIMEAS R devices you have PQ monitoring solved. In the case of a fault, you can react quickly and take the corresponding measures.

Optional modules and functions

- SICARO PQ - Analysis of power system quality, SICARO PQ allows fast analysis of measured power quality data according to EN 50160, IEC 61000-2-2 standards or based on customized settings. The measured values are automatically compared with the setpoint values and evaluated. After the analysis a report is automatically issued by the software. The report can be structured by the user with regard to form and layout. It is also possible to convert the complete report into HTML format.
- DIAGNOSE - Easy-to-use fault locator and diagnostic module
  The diagnostic module can automatically analyze the data of power transmission and distribution lines and calculate the distance to a fault. The diagnosis module can handle any number of segments or single lines. Handling of parallel lines as well as both ended fault location is also possible. If desired, the results are logically linked to the fault record and automatically printed or displayed on the monitor.
- COMTRADE - Import and export of fault records
  The COMTRADE function allows to import and export events which have been registered by devices of other manufacturers to be imported in accordance with the IEEE standard. Thus it is possible to import, edit and analyze stored fault events of another unit or system in OSCOP P.

Operating systems

- Windows 2000/XP Professional

Function overview

- Parameterization and remote configuration of SIMEAS R & OSCILLOSTORE P531
- Data transmission, data evaluation and data archiving for SIMEAS R/ OSCILLOSTORE P531 fault and quality recorder systems and numerical protection relays with IEC 60870-5-103 protocol
- Fully-automatic remote data transmission via dedicated line or telephone network with dial-up modem at a max. speed of 57,600 bit/s (connection also via ISDN) or Ethernet
- Network of several evaluation PCs (also in client-server mode), DAKON and SIMEAS R via LAN or WAN (TCP/IP) and therefore output on one or more power-system printers
- Fully-automatic display on the monitor or output of fault records - in the form of a sine wave or r.m.s. value curve (real r.m.s. value) - on printers and output of event logs
- Archiving of a large quantity of data with embedded database system

Evaluation functions

- Comfortable graphic evaluation program for analyzing recorded data, with extensive zoom functions, variable scaling, print preview.
- Computation of various line variables for the cursor position, e.g. impedance, reactance, active power, reactive power, apparent power, harmonics, peak r.m.s. values, voltage symmetry, etc.
- Filtering function for signals from protection relays
- Function for automatic creation of a power balance and tables for evaluating power quality

Optional functions

- DIAGNOSE: for automatic analysis of faults in the power system
- SICARO PQ: for automatic power quality analysis
- COMTRADE: Import and export of data according to the IEEE Comtrade standard.

Application

OSCOP P system program

OSCOP P is a PC program for retrieving and processing of records made with the SIMEAS R digital fault and power quality recorder, the SIMEAS Q power quality recorder, or with numerical protection relays using the IEC 60870-5-103 protocol.

The following tasks can be performed manually or automatically using OSCOP P:

- Retrieving measurement data from connected devices and storing it in the database
- Evaluation of data
- Visualization of results
- Output of results via a fax or printer
- Archiving of records

Appropriate installation of the OSCOP P on application- specific PC hardware enables the fault recorder system to perform its task without interruption.

DAKON PC

A number of devices (SIMEAS R, SIMEAS Q, protection relays) can be connected to a data concentrator PC (called the DAKON PC). A DAKON PC can collect the required data and automatically pass them on to a server PC.

Server PC

A number of DAKON PCs can be connected to one server PC. Data from the server PC can be retrieved and evaluated by several connected client PCs.

One server PC can pass on the collected data to a higher- level server PC.

Evaluation PC

A number of DAKON PCs, SIMEAS Rs and SIMEAS Qs can be connected to one evaluation PC. This configuration is primarily for local parameterization and data evaluation. An evaluation PC can also be installed in the office and connected to a DAKON PC or server PC.

Client PC

A client PC is connected to a server PC and is used for data evaluation. The client PC cannot pass on data to higher-level PCs.

Client-server network
All the above PCs can be interconnected via an Ethernet protocol. This ensures fast data exchange, e.g. between the PCs in several substations and a central server.

Data transfer

The remote data transfer between the PC and the connected units can be fully automatic. Here are some examples of possible communication links:

- Direct link, e.g. connection of numerical protection relays to an RS232 interface via a star coupler
- Connection of SIMEAS R and SIMEAS Q units via an analog or ISDN modem and public telephone network
- Networking of several evaluation PCs, DAKON PCs, server PCs and SIMEAS R via the Ethernet with the TCP/IP protocol.

Automatic operation

OSCOP P can be parameterized to perform many tasks either manually or automatically. Complete automation of tasks – such as retrieving data, evaluation, on-screen display, printing and faxing – can reduce the user's work-load. Addressing a device specifically and analyzing its data can also be performed manually.

Evaluation program

The evaluation program allows simultaneous display of any number of curves in any combination. Easy-to-use zoom functions, grid lines, several measuring cursors and additional calculations for diverse power system variables enable optimum evaluation of power system faults. Via the clipboard function, extracts from records can be re-used for a report in nearly all Windows applications, for example MS Word.

Peripheral equipment

OSCOP P can address all peripheral devices such as printers and faxes supported by the operating system.

Data processing

OSCOP P can perform the tasks of collecting data, writing it to the database, evaluating it, visualizing it, printing it and faxing it. This ensures uninterrupted functioning of the installed fault recorder system without intervention by maintenance personnel.

Supplementary functions (options)

DIAGNOSE (fault locator)
The optional "DIAGNOSE" software module performs automatic analysis of the fault records of power transmission and distribution lines. This function serves to compute a fault location on the line.
The result is presented in clear text. As part of the parameterization, the line can be divided into several segments to facilitate fault localization (applies to one-end calculation only). If the current and voltages of a parallel line are recorded, the inductive effect is automatically taken into account. If the data relating to a fault are available at both ends of a transmission line, the fault location can be determined more accurately from two sources. When parameterized accordingly, and with automatic data transfer, these functions are performed automatically. If desired, the results are logically linked to the fault record and automatically printed or displayed on the monitor. Power system faults can be filtered selectively to save time. Experts can then concentrate their efforts on more complex events.

Importing and exporting data
The additional "data import" function permits processing of events that have been recorded by devices of other manufacturers in OSCOP P. These data must be in Comtrade or ASCII format. The data are imported by OSCOP P and are available for further processing.
The additional "export" function can provide fault records of the SIMEAS R in the above format to other programs.

Supplementary functions (cont'd)

SICARO PQ analysis of power quality
This software package permits analysis of SIMEAS R measurement data (r.m.s voltage and current, frequency, THD, active and reactive power, etc.) based on the power quality standard EN 50160 or freely definable limits. The measured values are automatically compared with the setpoints and evaluated. After analysis, a report is automatically generated by the software, its structure and layout having been predefined by the user. It is also possible to convert the completed report to HTML format. In this format the report can be easily sent via e-mail. The HTML report can be visualized and printed out using an Internet browser. SICARO PQ also permits analysis of data measured by SIMEAS Q quality recorders. In conjunction with OSCOP P, measured values can be retrieved and analyzed automatically. The SICARO PQ software package is also available as single license software, permitting power quality analysis even without an OSCOP P license. However, automated operation is then not supported and the data required for power quality analysis must be provided in files.

Features

Parameterization

One important component of the parameterization is the definition of the network topology, followed by assignment of devices. The communication structure with individual devices and other PCs must then be configured in the OSCOP P program. When these steps have been performed each individual device can then be parameterized.

Definition of network topology

- Region(s)
- Substation(s)
- Feeder(s)
- Followed by assignment of each device to a region, substation, feeder and voltage level

Type of communication link to the PC per device:

- Null modem (direct link)
- Dedicated line modem
- Analog modem, including telephone number
- ISDN modem, including ISDN number
- Ethernet link (LAN / WAN), including TCP/IP number
- X.25 network, including X.25 address

Device password:

- For each SIMEAS R
- For each protection relay

Serial PC interfaces per device

- Address (in the PC)
- Baud rate
- Number of data bits
- Number of stop bits
- Parity

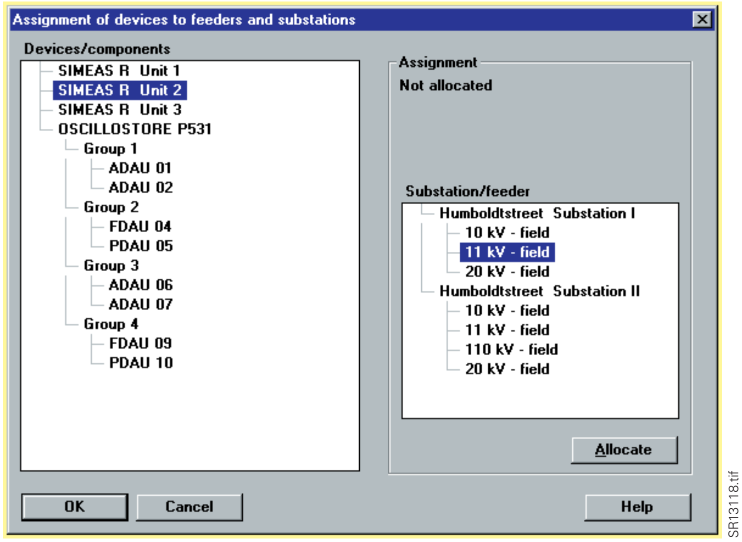


Fig. 13/118
Assignment of devices to feeders and substations

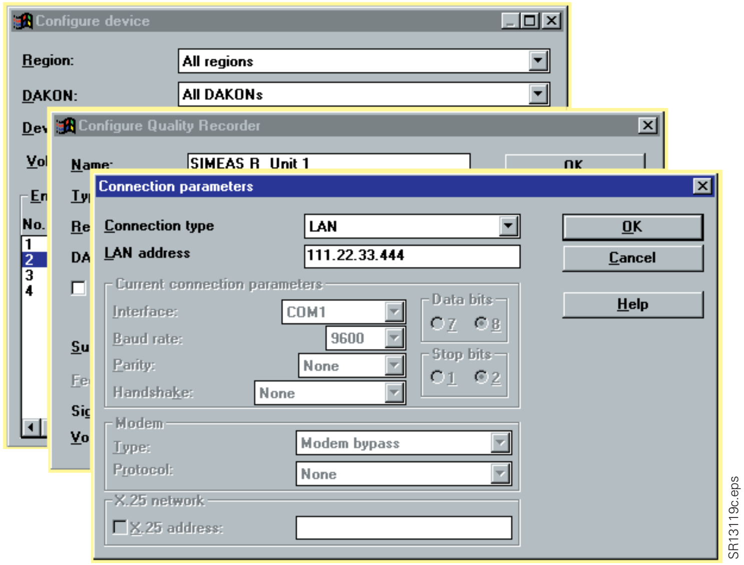


Fig. 13/119
Connection parameters

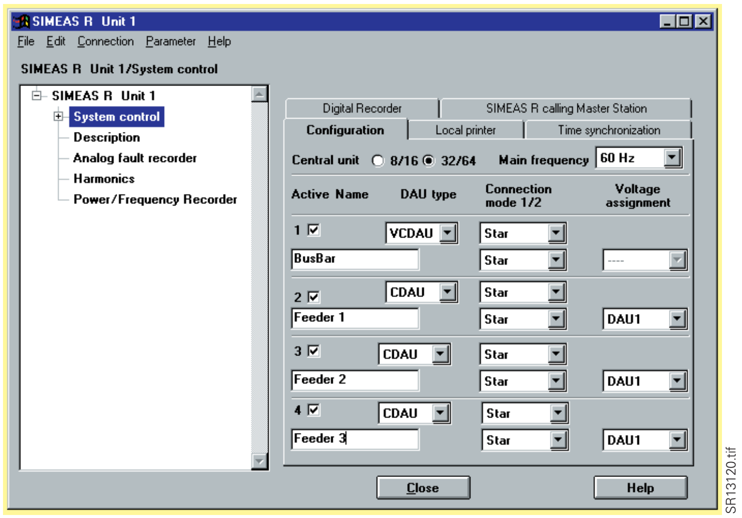


Fig. 13/120 Parameters for SIMEAS R/system control

13

Features

Parameterization (cont'd)

Program password

Depending on the requirements, different rights can be assigned to each user. This ensures coordinated parameterization of devices. The intention is to avoid non-harmonized parameterization of identical devices from different PCs.
The following access rights can be assigned:

a) Access to all functions is permitted
b) PC parameterization is disabled
c) Device parameterization and diagnosis are disabled, plus b)
d) All delete functions are disabled, plus c)
e) Retrieving data from lower-level PCs is disabled, plus d)

Storage of files / data base:

– Name of drive for storing the data
– Limitation of the database in Mbytes

Language setting for user interface

– English
– German
– French
– Spanish
– Italian

Parameterization of the SIMEAS R digital fault and power quality recorder

– Device designation
– Short identification of a measurement channel
– Channel legend
– Measuring range of a measurement channel
– Dimension of a measurement channel
– Color of a measurement channel
– System time
– Storage capacity per recording function
– Transmission type (ASCII or binary)
– Local printer

Activation of the functions

– Fault recorder
– Power and frequency recorder
– Mean value and power quality recorder
– Voltage dip and flicker
– Event recorder
– Report printer

- Parameterization of the fault record

– Trigger values
– Pre-fault recording
– Recording times
– Trigger disable

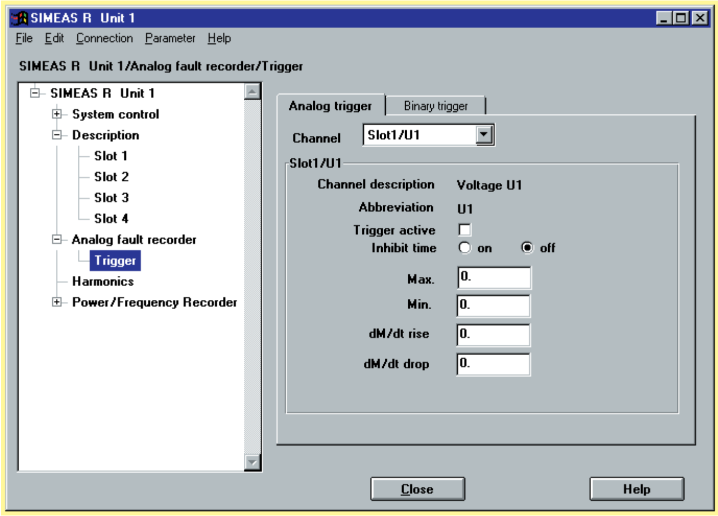


Fig. 13/121
SIMEAS R parameters/fault recorder/trigger settings

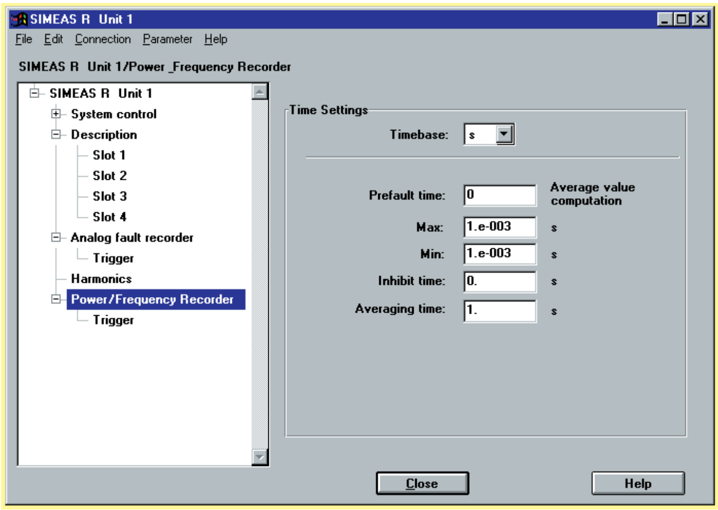


Fig. 13/122
SIMEAS R parameters/power/frequency recorder

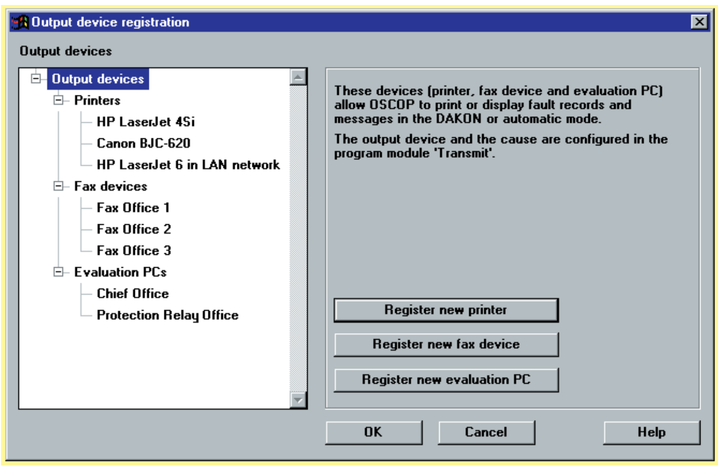


Fig. 13/123
Parameters of the output devices

Features

Parameters for automatic functions

Fault recordings can be automatically displayed on the screen, printed, faxed and exported in a predefined format.

Printing

- Fault records on/off per device
- R.m.s. value curve or sine wave per device
- Number of curves per sheet
- Max. number of sheets
- Time scale
- Amplitude scale
- Color display on/off
- Event log on/off per device

Fax transmission

- Telephone number for each fax terminal
- Designation of the fax terminal
- Assignment of a device to the fax terminal
- Fault record on/off per device
- R.m.s. value curve or sine waves per device
- Event log on/off per device

Display on the monitor

- Fault records on/off per device
- R.m.s. value curve or sine waves per device
- Event log on/off per device

Diagnostic function (option)

- Diagnostic function on/off per device
- Print-out on/off per device
- Output on monitor on/off per device

Export functions (ASCII, Comtrade)

- On/off per data type and device
- Indication of target drive and directory

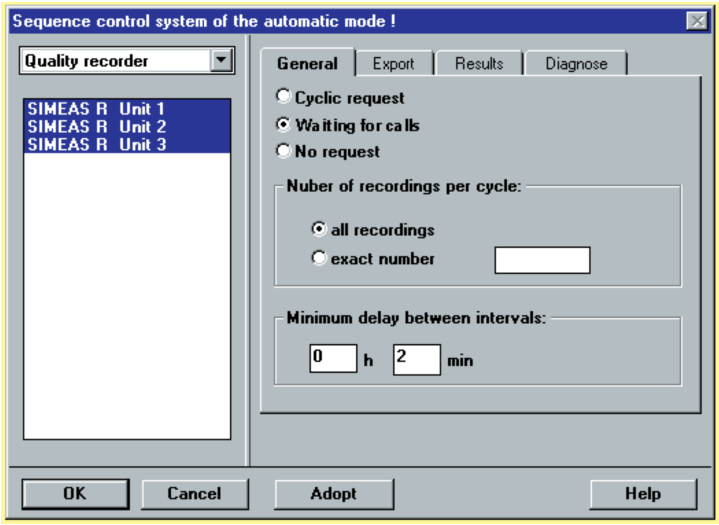


Fig. 13/124
Sequence control system of automatic mode

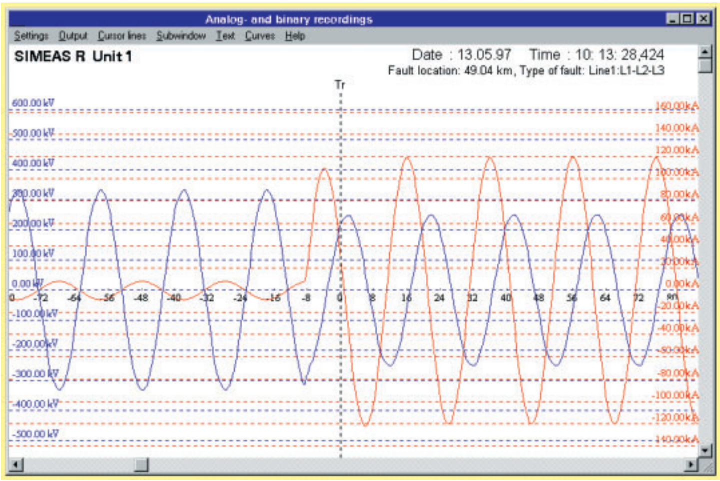


Fig. 13/125
Zoomed display of the current and voltage of a phase (with grid lines)

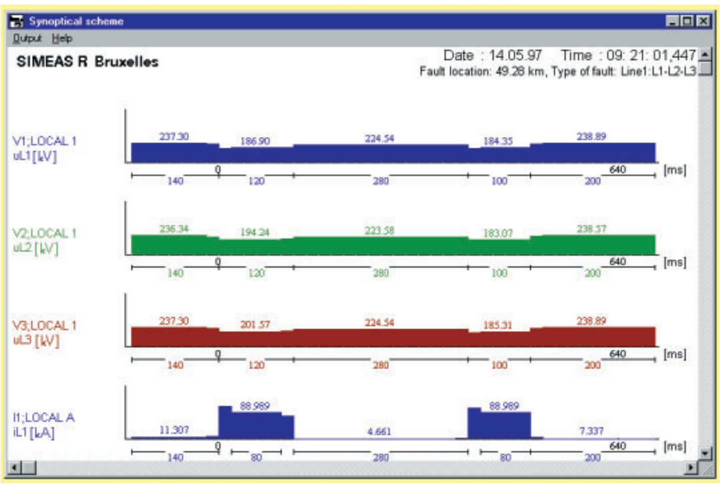


Fig. 13/126
R.m.s. value of a three-pole fault

Features

Automatic and manual data transfer

One or more SIMEAS Rs can be connected to a DAKON PC or server PC. Data transfer may be manual or automatic. A server PC retrieves the data either directly from the SIMEAS R or via a DAKON PC. Here are some examples of settings for data transfer.

Automatic data transfer

- Interrogation of all or selected systems
- Continuous operation via all available communications channels
- Time-controlled operation
- Transfer of header data with event information only
- Transfer of r.m.s value curve of DAKON PC only
- Transfer of diagnosis result of DAKON PC only
- Transfer of a combination of the r.m.s value curve or sine wave with the results of diagnosis
- Matching of the parameters between SIMEAS R, DAKON PC and OSCOP P

Manual sorting of records/ filtering function:

- Sorting by region
- Sorting by substation
- Sorting by voltage level
- Sorting by cause of recording
- Sorting by date and time
- Header data transfer
- Measurement data transfer
- Local print-out of events
- Local deletion of events
- Deletion of all manual starts
- Directory of all events
- Retrieve diagnosis results of DAKON PC
- Retrieve r.m.s value curve of DAKON PC
- Measuring signals (sine wave)
- Combination of measuring signal and r.m.s value curve with diagnosis results
- Interrogation of the status of SIMEAS R and DAKON PC

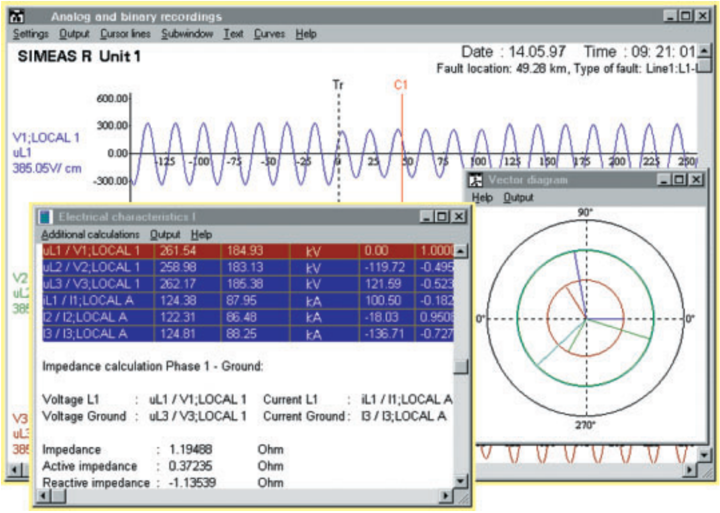


Fig. 13/127
Example of a measurement by cursor with vector diagram

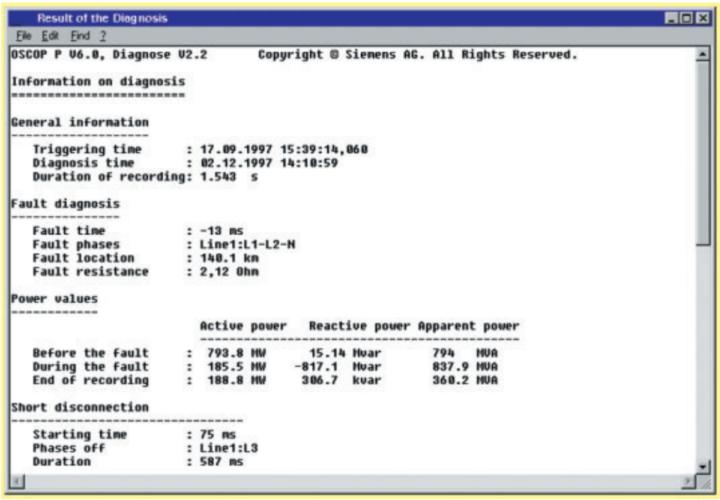


Fig. 13/128
Example of diagnosis results

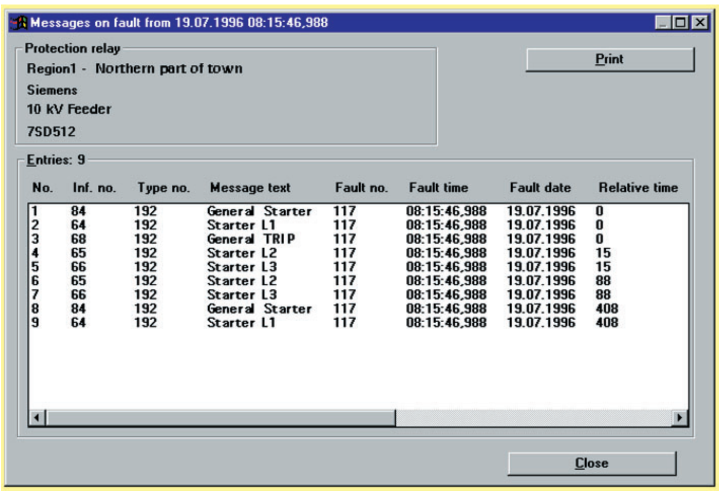


Fig. 13/129
Example of a protection relay event log

13

Features

Evaluation

Selection of the recording

Extensive filtering function covering region, substation, voltage level, feeder, date and time window, type of event, type of device, etc.

– All or selected channels
– Mixing of different systems and channels
– Changing the channel designation
– Changing the color of a channel

Display

– R.m.s value curve
– Instantaneous value curve (sine wave)
– Computed phase-to-phase voltages as instantaneous or r.m.s value
– Instantaneous values with grid lines
– Instantaneous values of several superimposed curves each with scaling
– Computed differential quotient ($\Delta M/\Delta t$) as a curve with time interval settable from 1ms to 99999 s
– Computed relative deviation ($\Delta M/M$) as a curve
– Computed absolute deviation (ΔM) as a curve

Zoom function
(positive and negative)

– Amplitude and time axis
– General zoom
– Channel-specific zoom
(for enlarging very small individual signals)
– Window zoom (magnifying function)
– Horizontal zoom
– Vertical zoom

Moving individually selected channels

– In x-direction
– In y-direction
– In x- and y-directions

Measuring

– Eight measuring value cursors for instantaneous value and time (including differences between the cursors)
– Trigger line (can also be used as a measuring value cursor)
– Data records can be moved from the value window to the clipboard and can then be integrated in a report.

Computation with reference to the cursor position

Calculation of all values is updated with cursor movements

– Amplitudes and r.m.s values
– Phase angle and power factor (PF) ($\cos\varphi$) relative to any channel
– Impedance and reactance between one phase and earth
– Impedance and reactance between two phases
– Active, reactive and apparent power; single or three-phase
– Voltage symmetry
– Vector diagram with selected curves (one curve is defined as the reference)
– 1^{st} to 21^{st} order harmonics and DC components as percentage or r.m.s value
– Total harmonic distortion

Print-out of the r.m.s value curves

– Print layout corresponding to the window contents on the monitor
– Complete print-out from the beginning to the end of recording

Print-out of the instantaneous value curve

– Print layout corresponding to the window contents on the monitor (full graphic resolution, no hardcopy)
– Complete print-out from the beginning to the end of the recording
– Print-out of the instantaneous value curve, including the computed curves (e.g. calculation of the phase-to-phase voltages from the phase-to-earth voltages)
– Print-out of all initially selected curves between two cursors
– All computed values in table form
– Vector diagrams

To transfer the window contents to other Windows applications with the highest possible graphic resolution, the clipboard function of the Windows operating system is used. A typical example is writing a report using a word processing program (for example MS Word).

Printing

On printers (also color) supported by the Windows operating system:

– All system parameters
– All curves
– All event logs
– All computed values
– All tables and
– Vector diagrams

Automatic print-out and display on the monitor

For the various possibilities, see parameters for the automatic functions

Measured-value and parameter files

- Import and export of measured-value and parameter files from diskette or hard disk
- Annotation of measured- value files with comments

Method of operation

DIAGNOSE with fault-locating function for transmission lines (option)

The optional DIAGNOSE software package is used with OSCOP P for calculating fault locations on a transmission line after a short-circuit. DIAGNOSE is software that supports the user in routine work. This module provides extensive setting options to calculate the fault location as accurately as possible.

Line segments

This module permits entry of several line segments, to take account of their differing properties, e.g. overhead line and buried cable segments.

Parallel lines

In the event of a fault on a line, the absolute error of the calculated fault location may be substantial if the inductive coupling of the parallel line is not taken into account. If the parameters of a parallel line are known, it is possible to improve the accuracy of the calculated fault location with correct parameterization of the DIAGNOSE program.

Double-end computation of the fault location

If the current and voltage signals of a line are registered at both ends by different SIMEAS Rs during a short-circuit, the fault location can be computed by evaluating both recordings. This calculation usually leads to a more accurate fault location.Appropriate parameterization of the substation and device assignment activates double-end computation.

Results

The result is output as an absolute value in km and as impedance in ohms. The fault type (e.g. phase L1-L2) is assigned to the measured-value files with a distance in km. On request, the peak and r.m.s values with phase angle are specified before and during the fault and the active, reactive and apparent power before, during and after the fault. The diagnostic result is displayed on the screen in clear text or output on the printer. With appropriate parameterization the result can be faxed via a DAKON PC or server PC. The explanatory component is implemented as a graphic curve display. Besides the fault location, time data concerning rapid auto- reclosure (RAR) and automatic reclosures (ARC) are stated.

Accuracy

For one-end fault localization, the error is typically 5 % with correct parameterization and low-resistance short-circuits. The algorithm used provides data about the accuracy of the fault location calculation (reliability data in %).

Parameters for the diagnostic module

The following parameters can be defined for the diagnostic module:

- Rated frequency
- Single or parallel line
- One or two-end calculation of the fault locations (only if recording devices have been installed at both ends)
- Number of line segments (for one-end calculation only)
- Line length per segment (for one-end calculation only)
- Positive sequence impedance per segment
- Negative sequence impedance per segment
- Allocation of the feeder currents to the respective voltages

Several parameter sets are possible per line; for example, the different line parameters for single or parallel line calculation. Changeover is performed manually.

The diagnostic software works either automatically or manually.

Data required for a single line:

– Phase currents L1, L2, L3

– Phase-to-earth voltages V_{L1}, V_{L2}, V_{L3}

Data required for a parallel line:

– Phase currents L1, L2, L3 per line

– Phase-to-earth voltages V_{L1}, V_{L2}, V_{L3} from busbar or per line

Additional function: Import and export of data (option)

With this additional module, all fault events can be imported and exported in a standard format complying with the international IEEE standard (Comtrade or ASCII format). This allows import of fault events from another device or system for processing with OSCOP P. Fault events exported according to this standard can be used for testing numerical protection relays with the aid of appropriate equipment.

Additional function: SICARO PQ analysis of power system quality (option)

SICARO PQ permits automated analysis of data and also generates an analysis report. The criteria for the evaluation of the analysis are limit values specified in the EN 50160 standard. This standard is preset, but analysis on the basis of application-specific limit values is also possible.

Networking of evaluation stations

OSCOP P expansion level “Server” permits design of a network of evaluation stations via a LAN or WAN (TCP/IP). In this case, a server PC or a DAKON PC is used as the server. All fault events of the connected fault recorders or numerical protection relays (IEC 60870-5-103) are read into the database and archived by this server.

OSCOP P can then run on any number of client PCs within the network (10 licenses are possible in the basic version).

Due to the fact that OSCOP P is installed completely at each workstation, autonomous data archiving is possible throughout a company, e.g. according to different areas of responsibility.

Configuration information

Operating system

– Windows 2000
– Windows XP Professional

Hardware requirements

Evaluation PC / Client PC

– Personal computer, 500 MHz processor or better
– RAM 512 Mbytes
– Hard disk, recommended minimum 10 Gbytes
– Color graphic card VGA or S-VGA
– Printers supported by the Windows operating system
– Mouse / keyboard for operation
– Network card as required

DAKON PC / Server PC

– Personal computer, 2 GHz processor or better
– RAM 512 Mbytes
– Hard disk, recommended minimum 40 Gbytes
– Network card as required
– Color graphic card VGA or S-VGA
– Printers supported by the Windows operating system
– Mouse / keyboard for operation

Selection and ordering data

Description	Order No.							
OSCOP P 6.5x system program	*7KE6010 – 1□*	*□*	*□*	*□ -*	*□*	*□*	*□*	*□*
For evaluation PC								
Level 1, with database for a max. of 1 device[1)]	A				0	B		
Level 2, with database for a max. of 5 devices[1)]	B				0	B		
Level 3, with database for a max. of 10 devices[1)]	C				0	B		
Level 4, with database for a max. of 1000 devices[1)]	D				0	B		
For DAKON XP								
Level 5, with database for a max. of 1000 devices with IEC 60870-5-103 protocol for communication with numerical protection relays. (Devices: see [1)])	E				0	B		
For server PC + 10 clients								
Level 6 with database for a max. of 1000 devices network server including 10 clients with IEC 60870-5-107 protocol for communication with numerical protection relays. (Devices: see [1)])	F				0	B		
Additional function 1								
With diagnosis software fault locator		A						
Without		B						
Additional function 2								
With Comtrade import and export function for disturbance records in accordance with the IEEE Comtrade standard			1					
Without			0					
Additional function 3								
With SICARO PQ for network quality analysis in accordance with EN 50160 and IEC 1000-2-2				1				
Without				0				
Additional function 4 (for server PC only)								
With SICAM archive including the additional function 2[2)]					1			
Without					0			
Additional function 5 (for server PC only)								
With Comtrade archive including the additional function 2[2)]						A		
Without						B		
Manual								
German							A	
English							B	
French							C	
Spanish							D	
Italian							E	
Supplied on the following data media:								
On CD-ROM (including manual in printed form and in the corresponding language)								0

Note:
Version 6.5x is not released for DAKON 98. Version 6.5x is only released for Windows 2000/XP Professional Edition.

1) Device: SIMEAS R, OSCILLOSTORE P531, protection relays with IEC 60870-5-103 protocol, unlimited number of SIMEAS Q

2) The application of this function must be clarified with the Product Management before ordering.

13

Selection and ordering data

Description	Order No.	Order Code
OSCOP P 6.5x dongle-free version	*7KE6010-2AA00 - 0A□□-Z X01*	

For users with a license agreement
for the dongle-free version.
The order is only valid if a copy of the signed
license agreement is sent to the factory.

Manual	
German	*A*
English	*B*
French	*C*
Spanish	*D*
Italian	*E*

Supplied on the following data media:	
On CD-ROM	*0*

Note: Version 6.5x is not released for DAKON 98.
Version 6.5x is only released for Windows 2000/XP Professional Edition

Description	Order No.
OSCOP P upgrade 6.x	

Upgrade of an existing dongle-connected, OSCOP P license
(version 6.1 or higher) to a higher level. Scope of delivery comprises
a software to reprogram the dongle for OSCOP P.
A dongle is not supplied.
An OSCOP P update (CD) or a manual must be ordered
separately, if required. When placing a purchase order,
please always submit the serial number of the original OSCOP P license.

Upgrade to a higher level	*7KE6010 –3A□□*
Level 1 to Level 2	*A*
Level 1 to Level 3	*B*
Level 1 to Level 4	*C*
Level 1 to Level 5	*D*
Level 1 to Level 6	*E*
Level 2 to Level 3	*F*
Level 2 to Level 4	*G*
Level 2 to Level 5	*H*
Level 2 to Level 6	*J*
Level 3 to Level 4	*K*
Level 3 to Level 5	*L*
Level 3 to Level 6	*M*
Level 4 to Level 5	*N*
Level 4 to Level 6	*P*
Level 5 to Level 6	*Q*

Supplied on the following data media:	
On 3½ inch floppy disks	*1*

13

Selection and ordering data

Description	Order No.
OSCOP P update 6.5x 1)	
Update for the version 6.1 / 6.3 / 6.40 to the current version of 6.5x	
Dongle-connected version	
Only for users with an existing license agreement for OSCOP P 6.1 / 6.3 / 6.40 Supplied without dongle, manual on documentation CD	
Current version of OSCOP P 6.5x on CD	C53207-A409-D997-1
Dongle-free version	
Only for users with an existing license agreement for the dongle-free version of OSCOP P 6.40 / 6.50 Supplied with manual on documentation CD	
Current version of OSCOP P 6.5x on CD	C53207-A409-D998-1
OSCOP P - update OLD	7KE6010 - 5A□□
Update of an older OSCOP P - license (Version 5.xx; 3.xx; 6.0) to the version 6.50 at the same level. Scope supply comprises a new dongle, OSCOP P 6.5x on data media and a manual. When placing a purchase order, please always submit the serial number of the original OSCOP P license. The old dongle has to be returned to the factory. Note: OSCOP P has to be installed completely new.	
Manual	
German	A
English	B
French	C
Spanish	D
Italian	E
Supplied on CD-ROM with dongle	0
OSCOP P additional functions 6.5x	7KE6010 - 4□A□
For the enhancement of the functionality of OSCOP P 6.5x after the first installation. Scope of delivery comprises a software to reprogram the dongle for OSCOP P. A dongle is not supplied. The corresponding software modules can be found on the original CD or floppy disks, except for SICARO PQ. If ordered, the current version of SICARO PQ is supplied on documentation CD Manual of SICARO PQ on documentation CD. OSCOP P update CD or manual must be ordered separately, if required. When placing a purchase order, please always submit the serial number of the original OSCOP P license. Note: Please note that ordering of additional functions is only possible with an original license + dongle	
Diagnosis software with fault locator	A
With import & export functions according to IEEE Comtrade standard	B
Network Quality Analysis - SICARO PQ	C
SICAM archive including option B 2) (for server PC only)	D
COMTRADE archive including option B 2) (for server PC only)	E
Supplied on 3 1/2 inch floppy disks, without dongle	1
Manual	
A manual is always supplied when ordering OSCOP P	
German	E50417-H1000-C170-A2
Italian	E50417-H1072-C170-A2
English	E50417-H1076-C170-A2
French	E50417-H1077-C170-A2
Spanish	E50417-H1078-C170-A2

1) The version 6.5x is not released for DAKON 98
The version 6.5x is released for the operating system WIN 2000 & WIN XP.

2) The application of this function must be clarified with the Product Management before ordering.

SICAM PAS
Substation Automation System

Fig. 13/130
SICAM PAS
Substation automation system

Description

SICAM PAS (**P**ower **A**utomation **S**ystem) meets all the demands made of a distributed substation control system – both now and in the future. Amongst many other standardized communication protocols SICAM PAS supports the new standard IEC 61850 in the substation for communicating with the bay devices. SICAM PAS is an open system and besides providing standardized data transfer processes, it features user interfaces for the integration of system-specific tasks and offers multiple automation possibilities.

SICAM PAS can thus be integrated with ease in existing systems and can be used for system integration too. With modern diagnostics, it optimally supports commissioning and maintenance.

SICAM PAS is clearly structured and reliable, thanks to its open, fully documented and tested system.

Function overview

System architecture

- Modular and scalable hardware and software
- Open system thanks to standards
- User-friendly due to Windows operating system
- Real-time data system
- Flexible, graphical configuration of automation
- Embedded industry platform

System features

- Real time changes in the configuration through database access
- Unrestricted access to information
- Monitoring and controlling switchgears via Web interface
- Substation control features, e.g. bay blocking, telecontrol blocking, security authority, time synchronization,
- Process visualization with SICAM PAS CC
- Evaluation of measured and metered values with SICAM Valpro
- Archiving of fault recordings of protection units with SICAM Recpro
- Testing and diagnostic functions
- OPC interface for connection to automation world
- IEC 61850 leading technology

Protocols

SICAM PAS supports the following communication protocols (optionally available):

- Control center connection
  IEC 60870-5-101,
  IEC 60870-5-104,
  DNP V3.00
- Open data exchange
  OPC server,
  OPC client
- IED and substation connection
  IEC 61850,
  PROFIBUS FMS,
  IEC 60870-5-103,
  IEC 60870-5-101,
  DNP V3.00,
  PROFIBUS DP,
  MODBUS
  SINAUT LSA-/LSA

13

Description/Application

System overview, application and functionality of SICAM PAS

- SICAM PAS is an energy automation solution; its system architecture makes it scalable.
- SICAM PAS is suitable for operating a substation not only from one single station computer (station unit), but also in combination with other SICAM PAS systems or station control units. Communication in this network is based on a powerful Ethernet LAN.
- With its features and its modular expandability, SICAM PAS covers a broad range of applications and supports distributed system configurations. A distributed SICAM PAS system operates simultaneously on several computers.
- SICAM PAS can use existing hardware components and communication standards as well as their connections.
- SICAM PAS controls and registers the process data for all devices of a substation, within the scope of the data transfer protocols supported.
- SICAM PAS is a communication gateway. This is why only one single data connection to a higher-level system control center is required.
- SICAM PAS enables integration of a fully graphical process visualization system directly in the substation.
- SICAM PAS simplifies installation and parameterization of new devices, thanks to its intuitive user interface.
- SICAM PAS is notable for its online parameter setting features, particularly when the system has to be expanded. There are no generation times, and there is no need for loading into a target system (unless configuration is performed on a separate engineering PC).
- SICAM PAS features integrated testing and diagnostic functions.
- Its user-friendliness, its operator control logic, its orientation to the Windows world and its open structure ideally suit users' requirements.

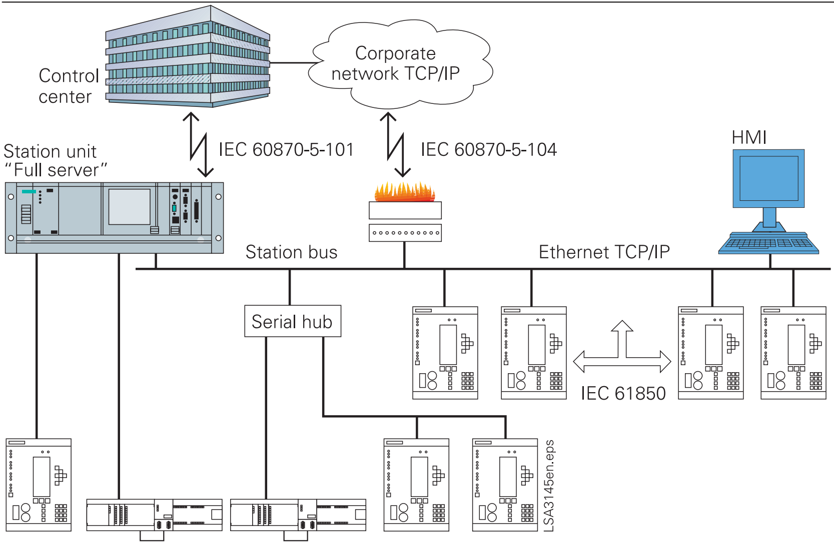


Fig. 13/131
Typical SICAM PAS configuration
IEDs are connected to the station unit with IEC 61850 and various other protocols (IEC 60870-5-103, IEC 60870-5-101, PROFIBUS FMS and PROFIBUS DP). The station unit communicate with the higher-level system control center by means of IEC 60870-5-104.

SICAM PAS works on PC-compatible hardware with the Microsoft Windows 2000, Windows XP Professional and Windows XP embedded operating systems. The advantages of this platform are low hardware and software costs, ease of operation, scalability, flexibility and constantly available support.

With the powerful real-time data distribution system, applications can be allocated among several computers, thus boosting performance, connectivity and availability.

A system stores and organizes the database (e.g. configuration data, administrative status data, etc.).

The device master function for communication with IEDs supports a large number of well-established protocols.

The SICAM PAS data normalization function allows such conversions as measurement filtering, threshold calculation and linear characteristics.

SICAM PAS CC is used for process visualization. Specifically designed for energy automation, it assists in optimization of ope- rations management. It provides a quick introduction to the subject matter and a clearly arranged display of the system's operating states.

SICAM PAS CC is based on SIMATIC WinCC, well-known in industrial automation worldwide.

To facilitate incident analysis, the fault recordings from protection units are retrieved and archived automatically during operation. This is supported by the IEC 61850 and PROFIBUS FMS (SIPROTEC 4) protocols, or the IEC 60870-5-103 protection units protocol. SICAM Recpro is used for archiving and navigation in the fault recording archive. Fault recordings are visualized with Comtrade View (included with SICAM Recpro). Alternatively, SIGRA 4 can also be used.

Communication

Device interfaces and communication protocols

In a substation that you configure and operate with SICAM PAS, you can use various types of protection units, IEDs, bay control units, measured-value recorders and telecontrol units from a wide range of manufacturers.

SICAM PAS offers a large number of commercially available communication protocols for recording data from various devices and through differing communication channels. Subsequent expansion is easy.

Available protocols

These communication protocols and device drivers can be obtained as optional additions to the standard scope of SICAM PAS.

IEC 61850

IEC 61850 is becoming the communication standard for interconnecting the devices at the bay and station control levels on the basis of Ethernet. IEC 61850 supports the direct exchange of data between IEDs, thus enabling switching interlocks across bays independently of the station control unit, for example.

PROFIBUS FMS

Most SIPROTEC 4 bay controllers and protection units (see Fig. 3) can be connected to the SICAM PAS station unit with PROFIBUS FMS. Many of the functional aspects standardized in IEC 61850 have been anticipated in this communication platform.

IEC 60870-5-103

Protection units, IEDs, bay control units, measured- value recorders and transformer controllers from many manufacturers support the IEC 60870-5-103 protocol and can therefore be connected directly to SICAM PAS.

IEC 60870-5-101 (master)

The IEC 60870-5-101 protocol is generally used to connect telecontrol units.

The 'balanced' and 'unbalanced' traffic modes are supported.

Automatic dialing is also supported for the connection of substations with this protocol.

SICAM PAS can establish the dial-up connection to the substation either cyclically or as required (e.g. for command output). By contrast, the substation can also establish a connection cyclically or in event-triggered mode.

Analog or ISDN modems can be used. A GSM modem can also be used in the substation.

Several modems are supported for communication with substations. Even if the 'standard modem' is already in use, other substations remain accessible.

PROFIBUS DP

PROFIBUS DP is a highly powerful field bus protocol based on the token passing method. For example, it is used for industrial automation and for automating the supply of electricity and gas.

PROFIBUS DP serves to interface multifunctional measuring instruments such as SIMEAS P (I, V, P, Q, p.f. ($\cos\varphi$)) or, for example, to connect ET200 components for gathering messages and for simple commands. Messages, for example, can be derived from the signaling contacts of fuse switch-disconnectors.

For simple applications that do not need functions like time synchronization and fault recording transfer, etc., SIPROTEC 4 units can also be interfaced via PROFIBUS DP.

IEDs and substations can also be connected with DNP V3.00 and MODBUS.

System control center connections, distributed process connection and process visualization

SICAM PAS operates on the basis of Windows 2000, Windows XP Professional and Windows XP embedded. This means that the extensive support which 2000/XP offers for modern communication protocols is also available with SICAM PAS.

SICAM PAS was conceived for easy and fast integration of conventional protocols. Contact Siemens if you have any questions about integration of user-specific protocols.

The standardized telecontrol protocols IEC 60870-5-101, IEC 60870-5-104 and DNP V3.00 (which is also used throughout the world) are supported for the purpose of linking up to higher-level system control centers.

Distributed process connection in the substation is possible thanks to the SICAM PAS Device Interface Processor (DIP).

SICAM PAS can also be set up on computers networked with TCP/IP. Here, one computer performs the task of the so-called full server. Up to six other computers can be used as DIPs. With this architecture, the system can be adapted to the topological situation and its performance also boosted.

SICAM PAS allows use of the SICAM PAS CC process visualization system for central process control and monitoring.

For industrial applications, it is easy to configure an interface to process visualization systems via OPC (object linking and embedding for process control).

SICAM PAS can be configured as an OPC server or as an OPC client.

The SICAM PAS process variables – available with the OPC server – can be read and written with OPC clients working either on the same device or on one networked by TCP/IP. This mechanism enables, for example, communication with another process visualization system.

The OPC server is included in the basic system.

The OPC client can read and write data from other OPC servers. Typical applications are data exchange with another SICAM PAS station unit, and the connection of SIMATIC programmable controllers.

The OPC client is available as an optional package.

SICAM Diamond

SICAM Diamond can be used to monitor the system interfaces, to indicate switching device states (and up-to-date measured values), and also for further diagnostic purposes.

SICAM Diamond features an event list and enables the issue of switching commands. SICAM Diamond allows access to data with a Web browser (Microsoft Internet Explorer), either on the same computer or from a Web client.

In other words:
SICAM PAS permits data access with Web-based programs.

Automation

Further station control aspects

SICAM PAS features bay blocking and telecontrol blocking functions. The telecontrol blocking function can also be configured for specific channels so as to prevent the transfer of information to one particular control center during operation, while transfer continues with other control centers. The bay blocking and telecontrol blocking functions act in both the signaling and the command directions.

Channel-specific switching authority also makes it possible to distinguish between local control (SICAM PAS CC) and remote control for the switching direction, but also between control center connections. Circuit-breakers can be controlled in synchronized/unsynchronized mode.

Automation tasks

can be configured in SICAM PAS with the CFC (Continuous Function Chart), which conforms to IEC 61131. In this editor, tasks are configured graphically by wiring function blocks. SICAM PAS comes with an extensive library of CFC function blocks, developed and system-tested specially for energy automation.

Applications range from generation of simple group indications through switching interlocks to complex switching sequences.

Redundancy

The SICAM PAS station unit can be used in a duplicate configuration to further boost the availability of the station control level (see Fig. 13/132). This duplication is possible with IEDs or substation devices that support simultaneous communication with two masters (PROFIBUS FMS, IEC 60870-5-101) or clients (IEC 61850).

Scope of information

The amount of information to be processed by SICAM PAS is essentially determined by the following factors:

- Computer network concept (multiple-computer network or single-station system)
- Performance data of the hardware used
- Performance data of the network
- Size of the database (RDBMS)
- Rate of change of values

A maximum of 150 IEDs and 10,000 data points can be processed.

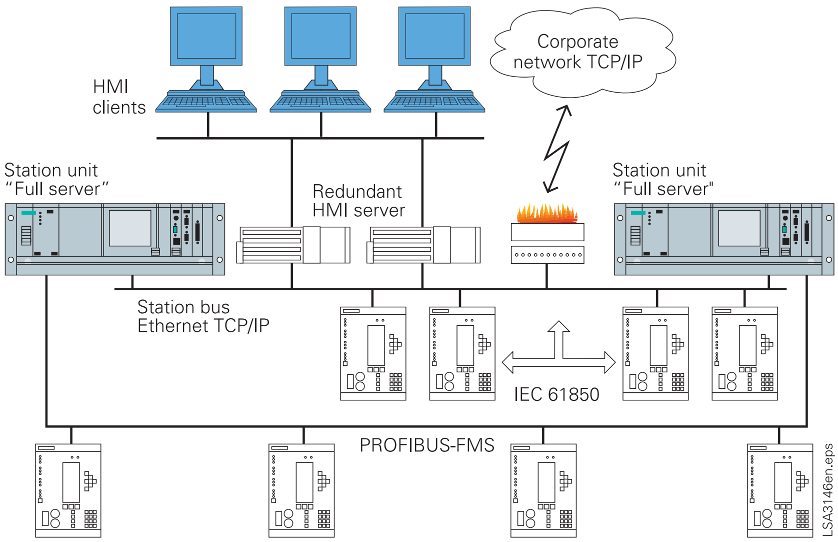


Fig. 13/132
Typical redundant configuration: The station unit and the HMI server are based on a redundant structure to boost availability

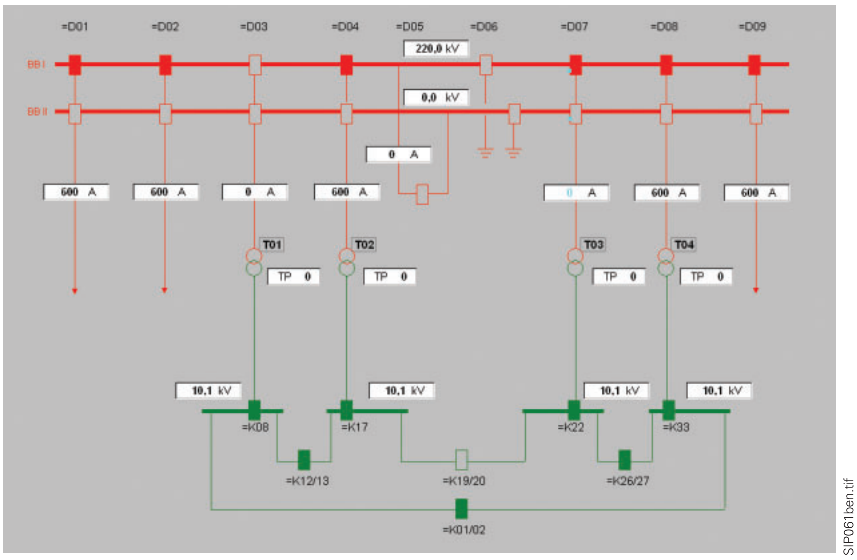


Fig. 13/133
Process visualization with SICAM PAS CC

13

Process Visualization

Process visualization with SICAM PAS CC (see also Fig. 13/133)

In the operation of a substation, SICAM PAS is used for configuration purposes and as a powerful data concentrator. SICAM PAS CC serves as the process visualization system.

SICAM PAS CC can be connected both to a SICAM PAS full server and to a SICAM PAS-DIP.

Several independent SICAM PAS CC servers can be connected to one SICAM PAS. Connection of redundant servers is also supported. SICAM PAS CC supports the connection of several SICAM PAS systems.

In the signal lists, the original time stamps are logged in ms resolution as they occur in the devices. With every signal, a series of additional data is also presented to provide information about causes (spontaneous, command), event sources (close range, local, remote), etc. Besides process signals, command signals are also logged.

IndustrialX-Controls are used to control and monitor switchgear. These switching device objects support four different forms of presentation (IEC, DIN, SINAUT LSA, SICAM) for circuit-breakers and disconnectors. It is also possible to create bitmaps (defined for a specific project) to represent switching devices, and to link them to the objects. For informative visualization, not only nominal and spontaneous flashing are supported, but also the display of various device and communication states (e.g. up-to-date/not up-to-date, bay and telecontrol blocking, etc.).

In conjunction with the SICAM PAS station unit, the switching devices can be controlled either directly or with “select before operate”.

The WinCC Add-on SIMATIC Web navigator can be used for control and monitoring via the Internet.

SICAM Valpro can be used to evaluate measured and metered values. It not only allows a graphical and a tabular display of archived values, but also enables subsequent evaluation functions such as minima, maxima and averages (on an hourly or daily basis).

SICAM Recpro supports automatic retrieval and archiving of fault recordings from protection units connected with IEC 60870-5-103, PROFIBUS FMS and IEC 61850.

SICAM PAS CC is based on SIMATIC WinCC, which has advanced to become both the industrial standard and the market leader in Europe. It has the following impressive features:

- Multilingual capability
- All operation and monitoring functions on-board.
  These include not only the graphics system for plant displays and the signaling and archiving system for alarms and measured values, but also a reporting and logging system. Further advantages are integrated user administration, along with the granting and checking of access rights for configuration and runtime operations.
- Easy and efficient configuration
  Configuration is assisted by dialogs, wizards and extensive libraries.
- Consistently scalable, even via the Web
  In conformity with requirements, the bandwidth ranges from simple single-user station through to distributed multi-user systems with redundant servers and multi-site solutions with Web clients.
- Open standards for easy integration
  Using any external tools, archived data can be accessed through a series of open interfaces (such as SQL and ODBC) for further editing.
  Manufacturer-independent communication with lower-level controllers (or with applications such as MS Excel) is supported with OPC (OLE for Process Control).
  Visual Basic for Applications (VBA), VBScript or ANSI-C create an ideal scope for project-specific solutions.
- Expandable with options and add-ons

– WinCC/Dat@Monitor
  serves to display and evaluate current process states and historical data on office PCs, using standard tools such as the Microsoft Internet Explorer or Microsoft Excel
– WinCC/Web Navigator
  is an option with SIMATIC WinCC for controlling and monitoring systems over the Internet, a company Intranet or a LAN
– WinCC/Connectivity Pack
  The functions of the two OPC servers HDA and A&E, and of the WinCC OLE-DB provider are ensured by the WinCC/Connectivity Pack.
– FunkServerPro
  With the aid of FunkServerPro, messages from the WinCC signaling system can be forwarded automatically to radio call receivers.

Configuration

Overview of the operator control philosophy and user interface

The SICAM PAS user interface is based on customary Windows technology, which enables you to navigate in the familiar Windows environment both when configuring the system and during ongoing operation.

The system distinguishes between configuration and operation of a substation. In SICAM PAS, these two tasks are firmly separated by two independent programs.

The SICAM PAS UI – Configuration program is used to create and edit a project-specific configuration. To enhance clarity, four views are distinguished:
– Configuration
– Mapping
– System topology
– Device templates

A common feature of all views is that they have an Explorer window that shows the system configuration in a clearly arranged tree structure. As in the Windows Explorer, you can open individual levels of this tree structure to work in them. Meanwhile, you can close other levels to improve clarity.

Depending on the level you are currently navigating in and the component you have chosen, in the context menu (right mouse button) SICAM PAS offers you precisely those program functions that are currently appropriate.

You work through the necessary steps in the data window on the right. Here, you set parameters, select information and define assignments to a user-specific, process-oriented system topology.

The user interface is uncomplicated and structured according to the task definition, so as to enable intuitive working and to simplify changes. The user interface assists the editing process by displaying parameter descriptions and messages when incorrect parameters are entered.

In the tabular views for information assignment and allocation to the system topology, configuration is made easy by extensive sorting and filtering mechanisms, multiple choices and Drag & Drop.

To ensure data consistency and to avoid redundant data input, SICAM PAS UI provides extensive import and export functions for the exchange of configuration data, e.g. with the bay control level and with process visualization.

Configuration

System requirements

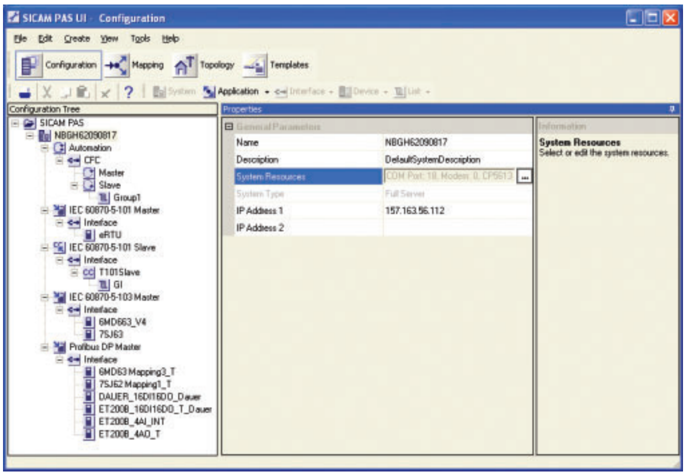
- Station unit with:
- Pentium processor III ≥ 800 MHz
- Main memory ≥ 256 Mbytes
- Hard disk capacity ≥ 512 Mbytes
- Graphics card for recommended resolution of ≥ 1024 x 768
- Color monitor matching the graphics card
- CD-ROM drive
- Keyboard
- Mouse
- Parallel printer interface
- Network adapter for LAN/WAN connection
- Interface cards for connection of IEDs
- SIMATIC CP5613/14 for connecting units with PROFIBUS DP interfaces
- e.g. Rocket Port COM Expander for serial connection of units with IEC 80670-5-103 interfaces, etc.
- Operating system
- Microsoft Windows 2000 Professional
- Microsoft Windows 2000 Server
- Microsoft Windows XP Professional Microsoft Windows XP embedded.

Test und Diagnosis

The SICAM PAS UI – Operation program features a series of editing and diagnostics views for monitoring and controlling a substation.

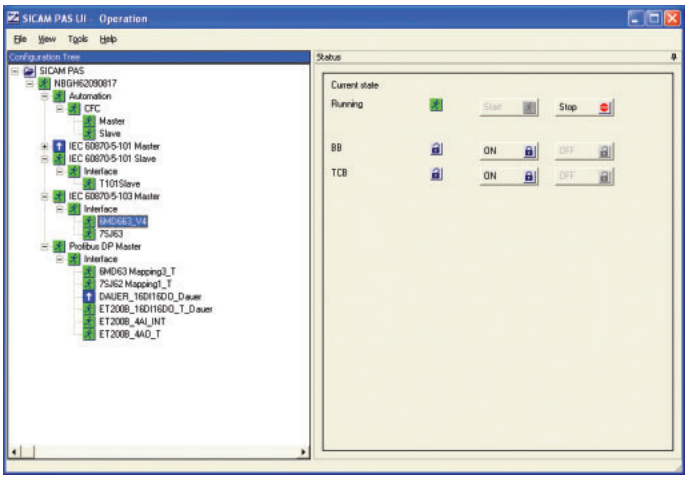
In the Operation Manager, you check and control the states of individual data connections.

In the SCADA Value Viewer you can see incoming values in a clearly arranged form and perform operator control actions for test purposes.



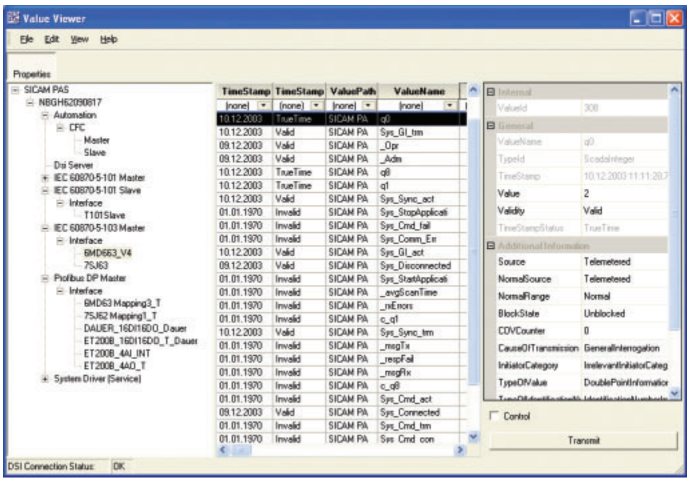
SIP062ben.tif

Fig. 13/134
SICAM PAS UI Configuration



SIP063ben.tif

Fig. 13/135
SICAM PAS UI Operation



SIP064ben.tif

Fig. 13/136
SICAM PAS Value Viewer

13

Selection and ordering data

Description	Order No.
Hardware	
SICAM PAS station unit	*6MD9100□□□□□-0AA0*
SICAM PAS station unit based on industrial microcomputer 19" rack system, fanless operation, without moving components CPU: LV Pentium III 933 MHz, 320 MB SDRAM PC133 1MB Flash EPROM, 512 kB BIOS / 512 kB user system Safety functions: HW watchdog, temperature / voltage monitoring of CPU Interfaces: 2 x RS232 (DB9m), 2 x USB (1.1), PS/2 mouse/keyboard, LAN: 10/100 (RJ45) Graphic on board: 1280 x 1024 / 16.7 million colors (DB15f); 10 LEDs Windows XP embedded SP2; Silicon Flash Disk SICAM PAS software preinstalled, without licence/dongle Note: SICAM PAS licence/dongle must be ordered separately	
Power supply	
24 V DC	*3*
60 V DC	*5*
110 / 125 V DC	*6*
110 -230 V AC	*7*
Configuration / operating system	
Flash disk 2GB / Windows XP embedded SP2	*A*
Language of operating system and SICAM PAS software	
German	*A*
English	*B*
PCI-adapter	
without PCI adapter	*0*
with PCI adapter	*1*
Function	
Full server (preinstalled)	*0*
Device interface processor (preinstalled)	*1*
Software[1]	
SICAM PAS	
Basic system including SICAM PAS UI – Operation SICAM PAS UI – Configuration (depending on the variant ordered) SCADA Value Viewer OPC-Server Real-time data distribution system Sybase SQL database	
Variants of the basic system	
"Full Server" (Runtime & Configuration) basic component as a single-user system or as the central component in a distributed system	*6MD9000-0AA00-5AA1*
"Full Server" (Runtime) basic component	*6MD9000-0AA10-5AA1*
"Full Server" (Configuration) basic component	*6MD9000-0AA20-5AA1*
Configuration Upgrade for one "Full Server" (Runtime)	*6MD9000-0AA23-5AA1*
Device Interface Processor (DIP) basic component for use as a subordinate component in a distributed PAS system (Runtime & Configuration)	*6MD9010-0AA00-5AA1*
Device Interface Processor (DIP; Runtime) basic component	*6MD9010-0AA10-5AA1*

1) Positions 13 and 16 of the software Order No. indicate the version. Version 5.1 is the current version (May 2005).

13

Selection and ordering data

Description	Order No.
Software (continued)	
Option packages for SICAM PAS Full Server and DIP:	
IEC 61850 (Client) for connecting IEDs	*6MD9000-0CE00-5AA1*
Driver for PROFIBUS FMS for connecting SIPROTEC 4 IEDs	*6MD9000-0CB02-5AA1*
Driver for PROFIBUS DP for connecting devices (e.g. SIPROTEC 4, SIMEAS P, S7-300, ET200, etc.)	*6MD9000-0CB01-5AA1*
IEC 60870-5-103 Master for connecting IEDs	*6MD9000-0CB00-5AA1*
IEC 60870-5-101 Master for connecting substations	*6MD9000-0CD00-5AA1*
IEC 60870-5-101 Slave for connection to higher-level control centers	*6MD9000-0CC00-5AA1*
IEC 60870-5-104 Slave for connecting to higher-level control centers	*6MD9000-0CC04-5AA1*
DNP V3.00 Master for connecting IEDs	*6MD9000-0CB07-5AA1*
DNP V3.00 Slave for connection to higher-level control centers	*6MD9000-0CC07-5AA1*
MODBUS Master for connecting sub-devices	*6MD9000-0CB05-5AA1*
SINAUT LSA-ILSA	*6MD9000-0CB03-5AA1*
OPC Client	*6MD9000-0BA40-5AA1*
CFC Automation	*6MD9000-0BA50-5AA1*

Description	Order No.
SICAM PAS CC *Human Machine Interface (HMI)* *Process visualization*	
Runtime	*6MD550□-0AP00-5AA1*
Runtime incl. evaluation applications SICAM Valpro, SICAM Recpro	*6MD550□-0BP00-5AA1*
Runtime & Configuration	*6MD551□-0AP00-5AA1*
Runtime & Configuration incl. evaluation applications SICAM Valpro, SICAM Recpro	*6MD551□-0BP00-5AA1*
128 tags	*1*
256 tags	*2*
1024 tags	*3*
8000 tags	*4*
64000 tags	*5*

13

Relay Communication Equipment

Table of contents see next page

Contents	Page

7XV5101
RS232-FO Connector Modules

Fig. 14/1

Fig. 14/2

Fig. 14/3

Fig. 14/1
Connector modules/adapters 7XV5101-0A

Fig. 14/2
Connector modules/adapters 7XV5101-0B

Fig. 14/3
Elbow plugs 7XV5101-8A / 7XV5101-8B

Description

Connector modules 7XV5101

Optical connection of protection relays with an electrical (non-isolated) RS232 interface, e.g. to a star coupler, for centralized control is made possible with the fiber-optic RS232 connector modules.

Thus, further devices such as PCs or notebooks, modems or serial data switches can be effectively protected against electromagnetic interference. An appropriate connector module is available for each of the above-mentioned applications. These fiber-optic RS232 connector modules are housed in a SUB-D plug casing and can be directly plugged into the respective interfaces of the pertaining devices. No further settings are required. In its normal position, the optical interface is set to steady light OFF. Data transmission is fully duplex and transparent. The optical interface with FSMA connectors has an operational wavelength of 820 nm and can reach distances of up to 1500 m with 62.5/125 µm multi-mode FO cables.

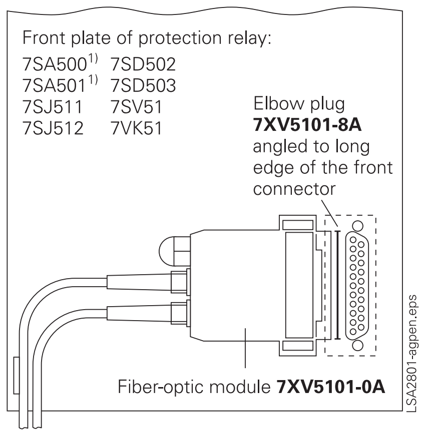
The various designs differ from each other in the number of pins (9 or 25 poles), in the design of the connector (male or female) and in their mode of auxiliary voltage supply (pin 9 from device or plug-in power supply unit (PSU). Further information on application and design can be obtained from the selection and ordering data.

Elbow plug 7XV5101-8

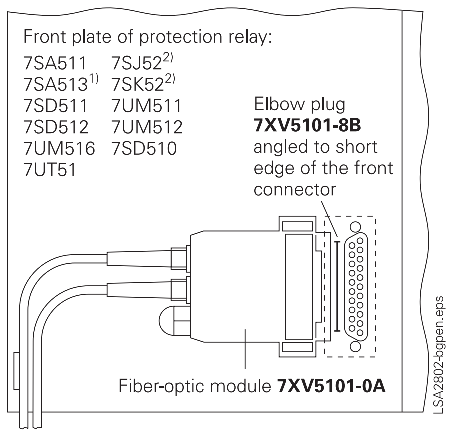
The 25-pin elbow plug allows an optical connection to be established between the protection relays and the star coupler or active mini star- coupler via the operator interface and fiber-optic connector modules. The front cover of the relay remains closed.

For the fiber-optic cables, a recess should be worked into the front panel frame so that the fiber-optic connector modules 7XV5101-0A can be conveniently placed underneath the front cover. The auxiliary voltage is supplied from the protection relay at its serial interface from pin 9.

The elbow plug is available in two different designs matching the different types of protection relays.



Mounting 7XV5101-8A



Mounting 7XV5101-8B

1) Connector on the left; fiber-optic outlet down to the right.

2) Connector on the right; fiber-optic outlet on the left passing through the cover.

Technical data

			7XV5101- 0A	0B	1B
Housing	Plastics, metal-plated		X	X	X
	Dimensions 58 x 53 x 17 mm		X	X	X
	Dimensions 72 x 32 x 17 mm				
Power supply	+ 5 V via pin 9 of the relay		X	1)	1)
	+ 5 V via female connector		X	X	X
	Plug-in PSU 220 V / 50 Hz (included in delivery)			X	X
	Via external keyboard connector located at the notebook				
Electrical interfaces	V.24 /RS232 DCE (steady light OFF)		X	X	
	V.24 /RS232 DTE (steady light OFF)				X
	DTE / DCE switchable		X	X	X
	Pin assignment 2 = TxD, 3 = RxD, 5 = GND				
	Pin assignment 3 = TxD, 2 = RxD, 5 = GND				
	Pin assignment 2 = TxD, 3 = RxD, 7 = GND				X
	Pin assignment 2 = RxD, 3 = TxD, 7 = GND		X	X	
	Pin assignment 9 = + 5 V		X	X	X
	Bridge contact 4 - 5, 6 - 8 - 20	25-pin	X	X	X
	Bridge contact 7 - 8, 1 - 4 - 6	9-pin			
Optical interfaces	FSMA connector (screw-type)	black = transmit, blue = receive	X	X	X
	FSMA connector (screw-type)	T = transmit, R = receive			
	Optical power	27 μW (- 15.7 dBm)2)	X	X	X
	Sensitivity	1 μW (- 30 dBm)2)	X	X	X
	Optical budget	7 dB (+ 3 dB backup)2)	X	X	X
	Wavelength 850 nm		X	X	X
	Transmission range	1500 m (with 62.5 μm multi-mode FO cable) 800 m (with 50 μm multi-mode FO cable)	X	X	X

1) Not available for 7XV5101-0B version/BB and 7XV5101-1B version/BB.

2) Valid for 62.5 μm FO cable.

Selection and ordering data

Description	Order No.
7XV5101 fiber-optic connector module 820 nm - RS232	*7XV5101-□□*
25-pin male connector for relays (V_{aux} pin 9 without PSU)	*0 A*
25-pin male connector for modem (with PSU 230 V AC)	*0 B*
25-pin female connector for PC/notebook (with PSU 230 V AC)	*1 B*

Description	Order No.
Elbow plug to 7XV5101-0A connector module	*7XV5101-□□*
Angled towards long edge of relay connector	*8 A*
Angled towards short edge of relay connector	*8 B*

7XV5103
RS485 Bus Cable System up to 115 kbaud

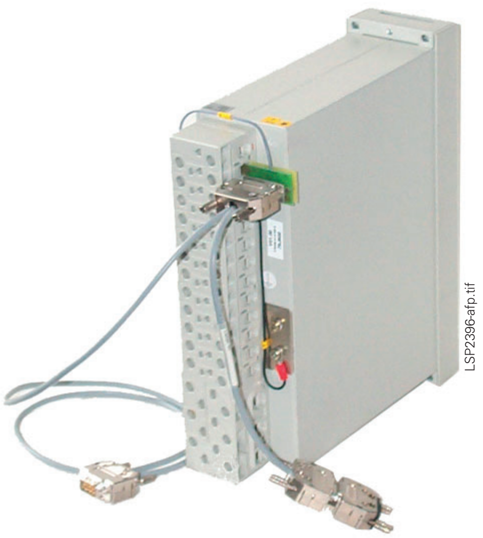


Fig. 14/4 RS485 bus cable system

Function overview

- Direct connection of the SIPROTEC 4 protection units with RS485 interface to the FO – RS485 converter 7XV5650
- Adaptor/cable for compact protection units, e. g. 7SJ600, 7SD600, 7RW600
- 4 cable lengths from 1 to 10 m
- Shielded twisted pair cables with 9-pin SUB-D connectors
- Metal plug casings with mechanical strain relief of the cable connections
- Compact plugs
- Baud rates of up to 115 kbaud
- Maximum extension of the bus up to 1000 m within the boundaries of an earthing system.
- Bus termination with termination plug with integrated 220 Ω resistor.

Description

Due to its relatively high immunity against interference, the RS485 bus, a cost-effective, half-duplex communication system, is increasingly applied in the utility corporations. Whereas previously it was mainly used in industry for monitoring and control purposes, it is now also often used in substations for control and protection purposes. Here, protocols such as DIGSI, IEC 60870-5-103 or VDEW, are used with baud rates of up to 115 kbaud to connect a master with up to 31 slaves via a shielded twisted wire pair (bus connection). Under ideal conditions, the length of this bus may be up to 1000 m. A prerequisite is that the bus is installed correctly, that appropriate cables and plug connectors are used, and that the bus is terminated correctly. Devices with different termination methods require special adapters to achieve the highest degree of immunity against interference. The RS485 bus system 7XV5103 is specially matched to the mentioned requirements of our control and protection product range.

Application

The 9-pin male connector of the Y-bus cable M1 always comes from the direction of the master, and provides the connection to the slaves via the 1, 3, 5 or 10 meter long cable and the 9-pin male connector M2. At the M2 plug, a 20 cm long cable with 9-pin female connector F3 is provided for extension of the bus. The compact protection units, e. g. 7SJ600, are connected via the adaptor cable 7XV5103-2AA00 with female connector F2 or directly with an RS485 converter 7XV5103-3AA00. Following the last unit, the bus is terminated with bus terminating resistor connector 7XV5103-0AA00 fitted to the F3 connector.

Notes on the RS485 bus

The housings of all slaves connected to the bus must be effectively earthed to a common earthing system to avoid dangerous currents flowing via the cable shield of the bus due to earth potential differences.

Larger distances, particularly to other buildings, should preferably be bridged with FO cables connected via converters (e. g. 7XV5651).

The RS485 bus must be radially configured (as in Fig. 14/5), i. e. no spur connections from the bus to the connected slaves are allowed, as this would correspond to a star configuration, which would have severe negative effects on the performance.

The bus must be terminated at the first device (in general, this is the master), and at the last device, with a bus terminating resistor of 220 ohm, to avoid interference due to reflection. No terminating resistors may be fitted in between.

As up to 32 devices (including master) are all communicating on the RS485 bus, they must all be set to the same baud rate and data format. Each slave must have a different device address. Within the system, only one master may be active, and only one slave may respond.

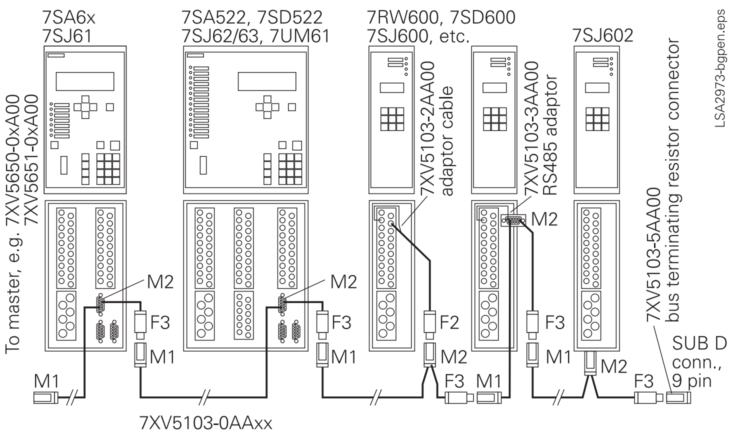


Fig. 14/5 Protection units connected to the RS485 bus

14

Selection and ordering data

Description	Order No.
7XV5103 RS485 bus system up to 115 kbaud	
RS485 Y-bus cable	*7XV5103-0AA□□*
Twisted pair with 9-pin SUB-D connectors	
Length 1 m	*0 1*
Length 3 m	*0 3*
Length 5 m	*0 5*
Length 10 m	*1 0*
RS485 bus extension cable	*7XV5103-1AA□□*
Twisted pair with 9-pin SUB-D connectors	
Length 10 m	*1 0*
Length 20 m	*2 0*
Length 30 m	*3 0*
Length 40 m	*4 0*
Length 50 m	*5 0*
Adaptor RS485	*7XV5103-□AA00*
Shielded cable with twisted wire pairs with crimp lugs/9-pin SUB-D connector for units with terminals or compact protection units, e. g. 7SJ600, 7SD6 etc.	*2*
RS485 adapter with 9-pin SUB-D connector for mounting with terminals on compact protection units, e. g. 7SJ600, 7SD6 etc.	*3*
Bus termination connector 220 Ω, 9-pin SUB-D connector	*5*
RS485 copper cable	*7XV5103-7AA□□*
For connection between the 7XV5662-□AD10 thermo-box and SIPROTEC 4 units (port C or port D with RS485 interface)	
Length 5 m	*0 5*
Length 25 m	*2 5*
Length 50 m	*5 0*

7XV5104
Bus Cable for Time Synchronization

Fig. 14/6 RS485 bus system

Function overview

- Opto-electrical solution for SIPROTEC 4 devices with IRIG-B interface (Port A)
- Direct connection of SIPROTEC 4 devices with IRIG-B interface to sync.-transceiver 7XV5654
- Adapter/cable for cascading and matching to other converters
- 4 orderable cable lengths from 1 m to 10 m
- 2-core, twisted and shielded cable with 9-pin SUB-D connectors
- Metal plug connector casings with fixing screws and strain relief for cable connections
- Compact dimensions of the plugs
- Max. extent of electrical bus 20 m within building

Description

The evaluation of fault records, operational alarms and fault signals calls for millisecond-accurate determination of the absolute time. The SIPROTEC 4 units have an internal clock on a quartz basis, which deviates from the normal time after a while. Radio clocks are therefore used for precise synchronization; they set the clocks in the devices via time signals or protocols such as DCF77 or IRIG-B. All the devices are connected in parallel with an electrical bus, so that all of them receive the time information at the same time at Port A. By means of the prefabricated bus cables and adapters 7XV5104 the SIPROTEC 4 units can be connected via their IRIG-B interface directly to the sync.-transceiver 7XV5654. The maximum length of the electrical bus when prefabricated cables are used is 20 m. Relevant applications are described in the manual for the sync.-transceiver 7XV5654.

Application

Notes on the IRIG-B bus

In this system solution only the 24 V DC time synchronization inputs of the SIPROTEC 4 units are used (see below). 7XV5105 cables are available for synchronizing the differential protection relays with an additional seconds pulse.

The housings of all bus users must be properly mutually earthed, as otherwise dangerous earth potential currents can flow via the bus cable shield.

Typical applications

The 9-pin male connector of the Y-bus cable S1 always comes from the direction of the radio clock or sync.-transceiver and provides via the 1, 3, 5 or 10 m cable and the 9-pin male connector the connection to the first and subsequent bus devices. At connector S2 a 9-pin female connector B3 is provided (on a 20 m long cable) to extend the bus. If more than six SIPROTEC 4 units are to be connected to the sync.-transceiver 7XV5654, the adapter 7XV5104-3AA00 splits the connection X1 of the sync.-transceiver into two buses for a maximum of 6 units each. (For typical applications see 7XV5654 manual).

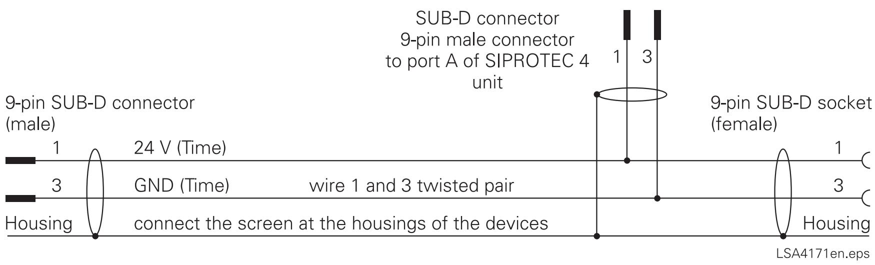


Fig. 14/7

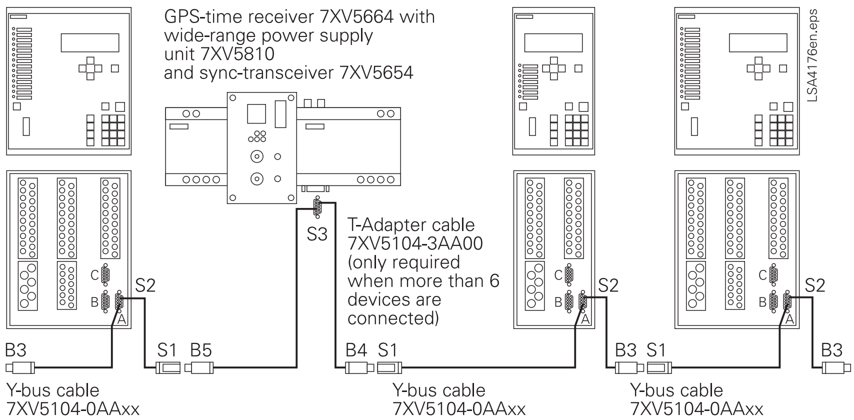


Fig. 14/8
Connection of max. twelve SIPROTEC 4 units to the IRIG-B bus via prefabricated Y-bus cable

Selection and ordering data

Description	Order No.
Y-connection cable IRIG-B / DCF77	*7XV5104-0AA□□*
Y-connection cable for SIPROTEC 4 unit with IRIG-B / DCF77 connection and bus extension. Copper cable 2-wire, shielded, with 9-pin SUB-D connectors	
Length 1 m	0 1
Length 3 m	0 3
Length 5 m	0 5
Length 10 m	1 0
Extension cable (copper)	
Cable for the bus length extension. Copper cable 2-wire, shielded, with 9-pin SUB-D connector Length 10 m	*7XV5104-1AA10*
Adapter / accessories	*7XV5104-□AA00*
Adapter cable to sync.-transceiver 7KE6000-8Ax, length 0.3 m, shielded, 2 wires with end sleeves to 9-pin SUB-D connector (female)	2
T-adapter cable to sync.-transceiver 7XV5654-0BA00 Splits connector X1 into 2 buses for max. six SIPROTEC 4 units per bus 9-pin SUB-D connector (male) to 2 x 9-pin SUB-D connector (female) Copper cable 2-wire, shielded (length 0.3 m)	3

14

7XV5105
Bus Cable for Time Synchronization (for 7SD5 Relays)

Fig. 14/9 Y-cable 7XV5105

Function overview

- Opto-electrical solution for SIPROTEC 4 7SD5 differential protection relays with IRIG-B interface (Port A)
- Direct connection of 7SD5 protection relays via IRIG-B interface to sync.-transceiver 7XV5654
- Transmission of time telegram and seconds pulse at the same time
- 4 orderable cable lengths from 1 m to 10 m
- 4-wire, twisted and shielded cable with 9-pin SUB-D connectors
- Metal plug connector casing of compact dimensions, with fixing screw and strain relief for cable connections
- Max. extent of electrical bus 20 m within building

Description

The evaluation of fault records, operational alarms and fault signals calls for a millisecond-accurate absolute time stamp. The differential protection relays have an internal clock on a quartz basis, by means of which the protection is normally synchronized. In special applications, GPS radio clocks are used to synchronize the 7SD5 differential protection relays with the absolute time. These clocks send a time telegram together with a microsecond-accurate seconds pulse, so that the transmission time in both the sending and the receiving direction can be precisely measured. All the devices in each system are connected in parallel via an electrical bus, so that all devices receive the time information and the seconds pulse at the same time. By means of the prefabricated bus cables 7XV5105, the 7SD5 relays can be connected via their IRIG-B interface (Port A) directly to the sync.-transceiver 7XV5654. The maximum length of the electrical bus when the prefabricated cables are used is 20 m. Relevant applications are described in the manual for the sync.-transceiver 7XV5654.

Application

Notes on the IRIG-B bus

In this system solution only the 24 V DC time synchronization inputs (Port A) of the SIPROTEC 4 protection relays are used. 2-core 7XV5104 cables are available for time synchronization of the SIPROTEC 4 protection relays without additional seconds pulse.

The housings of all bus users must be properly mutually earthed, as otherwise dangerous earth potential currents can flow via the bus cable shield.

Typical applications

The 9-pin male connector of the Y-bus cable S1 always comes from the direction of the radio clock or sync.-transceiver and provides via the 1, 3, 5 or 10 m cable and the 9-pin male connector the connection to the first and subsequent bus devices. At connector S2 a 9-pin female connector B3 is provided (on a 20 m long cable) to extend the bus. If more than six SIPROTEC 4 units are to be connected to the radio clock, up to 4 sync.-transceivers 7XV5654 can be connected, each with 6 protection relays. (For typical applications see the 7XV5654 manual).

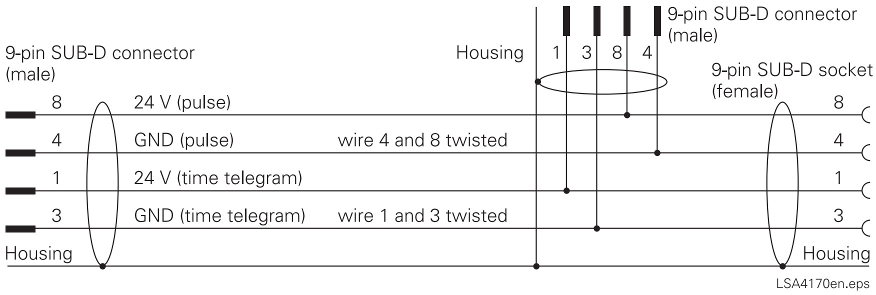


Fig. 14/10

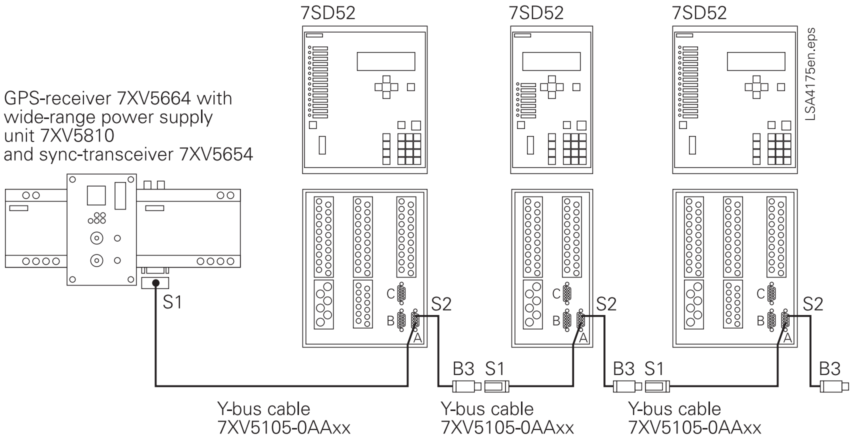


Fig. 15/11
Connection of max. six SIPROTEC 4 protection relays 7SD5 to the IRIG-B bus via prefabricated Y-bus cable

Selection and ordering data

Description	Order No.
Y-connection cable IRIG-B / DCF77	*7XV5105-0AA□□*
Y-connection cable for direct connection of a SIPROTEC 4 differential protection relay with IRIG-B / DCF77 connection to sync.-transceiver 7XV5654 and bus extension. Copper cable 4-wire, shielded, with 9-pin SUB-D connectors	
Length 1 m	*0 1*
Length 3 m	*0 3*
Length 5 m	*0 5*
Length 10 m	*1 0*
Extension cable (copper)	
Cable for bus length extension. Copper cable with 4 wires, shielded with 9-pin SUB-D connectors	
Length 10 m	*7XV5105-1AA10*
Adapter / accessories	
Adapter cable to two sync.-transceivers 7KE6000-8Ax, length 0.3 m shielded, 2 wires with end sleeves to 9-pin SUB-D connector (female)	*7XV5105-2AA00*

7XV5300
Star Coupler

Fig. 14/12
Star coupler

Description

With this fiber-optic star coupler, the messages of the relay operating software DIGSI or IEC 60870-5-103 protocol are distributed to all relays via a maximum of 30 fiber-optic interfaces. The transmitting FO interface (FO port) of the star coupler's expansion unit is connected to the relay's receiving FO interface. Every message contains an address so that only the corresponding relay will answer. This relay now sends the answer back to the operator PC via the expansion module's receiving FO interface and the main module's transmitting FO interface.

Function overview

- Up to 30 SIPROTEC relays can be remotely operated via fiber-optic cables
- The smallest assembly unit consists of a main module including a power supply unit (PSU) and an expansion module with 3 FO interfaces
- Up to 9 additional expansion modules can be installed later, making communication via 30 FO interfaces possible
- The star-coupler is cascadable
- All fiber-optic interfaces (full duplex) have FSMA connectors and the steady-light indication can be set to ON or OFF individually (manufacturer's presetting: "OFF")
- An RS232 interface with a 9-pin SUB-D miniature connector allows the relays also to be operated locally
- The fiber-optic interface on the main module is inactive when the RS232 interface is being used
- Data is transmitted transparently, i.e. independent of any protocol
- The wavelength of all ports is 850 nm
- The max. distance between star coupler and relay is approx. 1.5 km
- The power supply covers the following voltage ranges without switching: 48 - 250 V DC and 110 - 220 V AC. The power supply has been designed for the maximum configuration
- Every module has 3 LEDs: one for the operating voltage (green), one for the flow of data (yellow) and one in case of disturbance (red)

Hardware

- The star-coupler together with its integrated power supply unit is housed in a 19" subrack

14

Application

Via the modular star coupler, up to 30 SIPROTEC protection units with an optical interface can be connected optically to a PC for remote operation.

In this way, interference-free connection between local relays and a central operation unit can be established via FO cables. With the use of optical interfaces, any potential transfer within the substation is avoided.

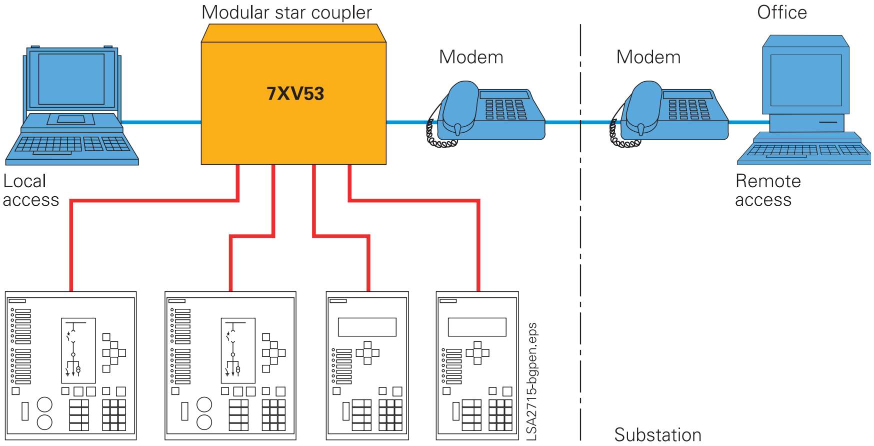


Fig. 14/13
Application configuration

Selection and ordering data

Description		Order No.
7XV5300 modular star coupler		*7XV5300-0□A00*
Number of relays to be operated		
No expansion module		A
With 1 expansion module	for 3 relays	B
2 expansion modules	for 6 relays	C
3 expansion modules	for 9 relays	D
4 expansion modules	for 12 relays	E
5 expansion modules	for 15 relays	F
6 expansion modules	for 18 relays	G
7 expansion modules	for 21 relays	H
8 expansion modules	for 24 relays	J
9 expansion modules	for 27 relays	K
10 expansion modules	for 30 relays	L
Spare parts		
Main module		*7XV5301-0AA00*
Expansion module		*7XV5302-0AA00*

14

7XV5450
Mini Star-Coupler

Fig. 14/14
Mini star-coupler

Function overview

One optical input and up to 4 optical outputs

- Distance spanned: 1.5 km with 62.5/125 µm multi-mode fiber
- Multiple mini star-couplers cascadable
- RS232 interface for local access
- Baud rate via FO: up to 1.5 Mbaud; Baud rate with RS232: Up to 115 kbaud
- Protocol transparency
- Light idle state: Light ON/light OFF selectable
- Wide-range power supply with self-monitoring function and alarm contact
- Optical ST connectors

Description

The mini star-coupler multiplies an optical signal received at an input for up to four outputs. A signal received at one of the outputs is transmitted via the input interface to a central unit or to an upstream mini star-coupler or converter. As the mini star-coupler does not transmit selectively to individual outputs, the protocols used for data transmission must operate with unique DTE addresses, so all units “hear” the central interrogation, but only the addressed unit answers to the request (e.g. IEC 60870-5-103 or DIGSI).

Data are transmitted in transparent full-duplex mode. An RS232 interface is provided for direct serial communication with DTEs at each mini star-coupler. As long as this interface is in use, the optical input interface to the central unit is blocked.

Cascading mini star-couplers replace the 7XV5300 star coupler.

Application

The mini star-coupler allows SIPROTEC relays to be centrally accessed or remotely interrogated with DIGSI via optical interfaces. The component is cascadable, so that star topologies or ring topologies can be configured. A ring structure ensures that all four outputs are used. The mini star-coupler has a local RS232 interface socket. By connecting a PC to this interface and using the 7XV5100-4 cable, the optical input is disconnected to avoid data collision due to local and remote access concurring at the same time.

Construction

The 7XV5450 mini star-coupler is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

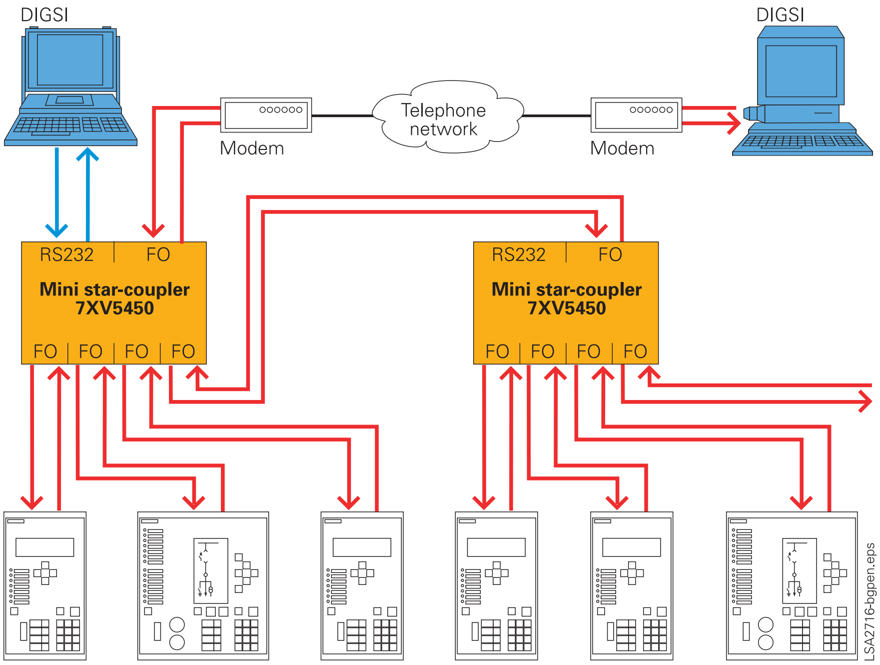


Fig. 14/15 Star topology with mini star-couplers

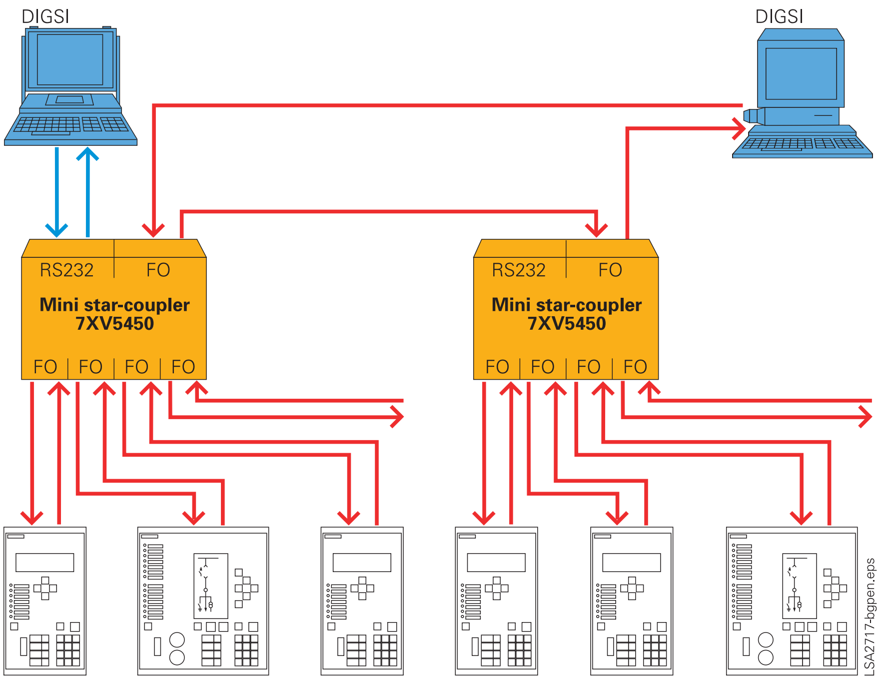


Fig. 14/16 Ring structure with mini star-couplers

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
Current consumption	
Approx. 0.25 to 0.4 A	
LEDs	
3 LEDs Green Yellow Yellow	 Operating voltage o.k. Receiving data Sending data
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO cables	Multi-mode fiber with ST connectors
RS232	9-pin SUB-D socket
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	By jumpers
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting on 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV5450 mini star-coupler	*7XV5450-0BA00*

Optical mini star-coupler with plastic housing for snap-on mounting onto 35 mm rail.

Rated auxiliary voltage 24 - 250 V DC and 110 - 220 V AC with alarm relay.

Connection of up to 4 protection units to a star coupler via FO cable for 62.5 / 125 μm and 850 nm wavelength, max. distance 1.5 km.

Connection of PC or modem to a star coupler via FO cable for 62.5 / 125 μm and 850 nm wavelength, max. distance 1.5 km.

Connection also by 9-pin RS232 connector.

Cascadable

Fiber-optic connectors with ST connector

7XV5461
Two-Channel Serial Optical Repeater (for mono-mode FO cables)

Fig. 14/17
Optical repeater with
wide-range power supply

Function overview

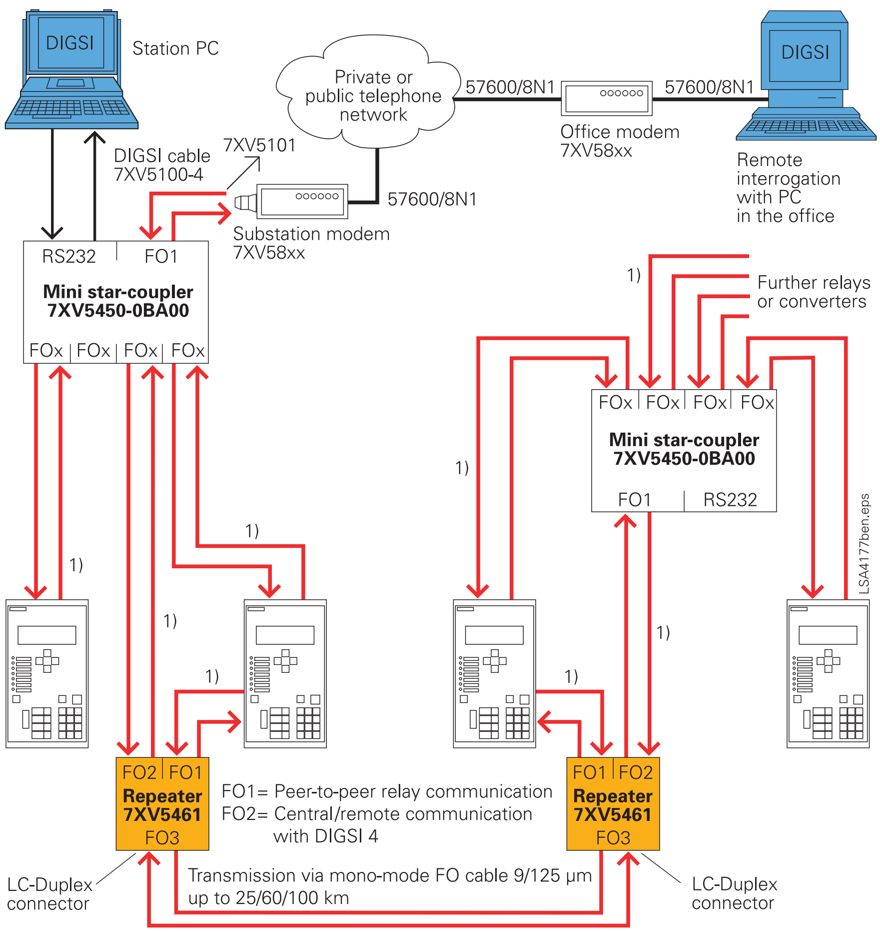
- Two independent multiplexed 820 nm ports with ST connectors for max. 1.5 km via 50/125 µm and 62.5/125 µm multi-mode FO cable.
- Data rate of serial ports 1 / 2 from 300 bit/s - 4.096 Mbit/s. Automatic baud rate adjustment to synchronous and asynchronous serial signals; no settings necessary.
- Powerful 1300 nm / 1550 nm port with LC- Duplex connector for distances up to 24 km / 60 km / 100 km via 9/125 µm mono-mode FO cable
- 24 to 250 V DC and 115/230 VAC wide-range power supply with alarm relay.
- Data exchange display by LED
- Integrated commissioning support

Description

The optical repeater transmits serial optical signals over long distances via mono-mode FO cables. It converts serial optical 820 nm signals at Port 1 and Port 2 in the range of 300 bit/s to 4.096 Mbit/s. Both synchronous and asynchronous signals can be connected. Two independent, serial 820 nm inputs with ST connectors are available, which are multiplexed to Port 3. Two devices with an optical 820 nm interface, for example the 7SD5 / 7SD6 line differential protection relay or the RS232/820 nm 7XV5652 converter, can be connected to Ports 1 and 2 via multi-mode FO cables for distances of up to 1.5 km. Signal transmission at Port 3 is achieved via the LC-Duplex connector at wavelengths of 1300nm/ 1550 nm for connection of a mono-mode FO cable. For Port 3 there are three options for max. 25 km (1300 nm) / 60 km (1300 nm) and 100 km /1550 nm) optical fiber lengths. The device can be connected to all battery voltages and AC supply sources. Loops can be activated for Ports 1 / 2 for commissioning purposes, so that the input signals can be mirrored at the port in question.

Typical applications

The protection relays (for example 7SD5 / 7SD6 differential protection or 7SA52 / 7SA6 distance protection) exchange information via Port 1. Interference-free data exchange is made possible by mono-mode FO cable up to a distance of 100 km. Protection remote control with DIGSI is connected to Port 2 of the repeater via the 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC where DIGSI is installed. The protection relays on the remote substation can be scanned remotely via Port 2. The baud rate is optimally set to 57.6 kbit/s so that there is no divergence from local operation. During commissioning and operation, data of the device in the other substation can be changed and read out. Alternatively, it is possible to connect power system control or additional protection data transmission to Port 2. This makes optimum use of the long-distance optical fiber for two independent serial connections for transmitting data between 300 bit/s and 4.096 Mbit/s.



1) Multi-mode FO cable with ST connectors (6XV8100)

Fig. 14/18
Transfer of protection data and remote control of a substation via an optical long-distance connection

Technical data

Connections	
Ports 1 / 2	ST connector for 820 nm for 50/125 µm and 62.5/125 µm multi-mode FO cable
Port 3	LC-Duplex connector for 1300 nm/1550 nm for 9/125 µm mono-mode FO cable
Screw-type terminals	2-pole screw-type terminals for auxiliary voltage supply 3-pole make/break contact for alarm relay
Housing	
188 x 56 x 100 mm aluminum housing for mounting on 35 mm DIN rail to EN 50032. Weight 0.8 kg. Degree of protection acc. to EN 60529: IP41	
Power supply	
Wide range 24 to 250 V DC without connector jumpers, 115 / 230 V AC	
Displays	
4 LEDs	
Green	Power supply
Red	Alarm relays
2 yellow	Data exchange

Selection and ordering data

Description	Order No.
7XV5461 two-channel serial optical repeater (for mono-mode FO cables)	*7XV5461 - 0B☐00*
Connection of two serial optical inputs with ST connector for 62.5/125 µm multi-mode FO cable up to 1.5 km, from 300 bit/s to 4.096 Mbit/s 24 to 250 V DC, 115/230 VA C wide-range power supply Fault relay and LED for operational and fault display	
Optical 1300 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 25 km (permissible path attenuation 13 dB)	*G*
Optical 1300 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 60 km (permissible path attenuation 29 dB)	*H*
Optical 1550 nm output with LC-Duplex connector for 9/125 µm mono-mode FO cable for distances up to 100 km (permissible path attenuation 29 dB)	*J*

14

7XV5461
Two-Channel Serial Optical Repeater (for multi-mode FO cables)

Fig. 14/19
Optical repeater with
wide-range power supply

Description

The optical repeater transmits serial optical signals over long distances via multi-mode FO cables. It converts serial optical 820 nm signals at Port 1 and Port 2 in the range 300 bit/s - 1.5 Mbit/s to 1300 nm for multi-mode fiber cables. Both synchronous and asynchronous signals can be connected. Two independent, serial 820 nm inputs with ST connectors are available, which are multiplexed to Port 3. One transmit (Tx) and one receive (Rx) signal is supported (no RTS/CTS handshake signals). Two devices with an optical 820 nm interface, for example the 7SD52 / 7SD610 line differential protection relay or the RS232/820 nm 7XV5652 converter, can be connected to Ports 1 and 2 via multi-mode FO cables for distances of up to 1.5 km. Signal transmission at Port 3 is achieved via the LC-Duplex connector at wavelengths of 1300 nm for connection of a multi-mode FO cable. For Port 3 there are two options for a max. of 4 km (1300 nm) and 8 km (1300 nm) optical fiber lengths. The device can be connected to all battery voltages and AC supply sources. Loops can be activated for Ports 1 / 2 for commissioning purposes, so that the input signals can be mirrored at the port in question.

Function overview

- Two independent multiplexed 820 nm ports with ST connectors for a max. of 1.5 km via 50/125 µm and 62.5/125 µm multi-mode FO cable.
- Data rate of serial ports 1 / 2 from 300 bit/s - 1.5 Mbit/s. Automatic baud rate adjustment to synchronous and asynchronous serial signals; no settings necessary.
- Powerful 1300 nm port with LC-Duplex connector for distances up to 4 km /8 km via 50/125 µm / 62.5/125 µm multi-mode FO cable
- 24 to 250 V DC and 115/230 V AC wide-range power supply with alarm relay.
- Data exchange display by LED
- Integrated commissioning support with test loop feature

Typical applications

Two protection relays (for example 7SD52/7SD610 differential protection or 7SA52/7SA6 distance protection) exchange information via Port 1. Interference-free data exchange is made possible by optical multi-mode FO cable up to a distance of 4/8 km. Protection remote control with DIGSI is connected to Port 2 of the repeater via 7XV5450 mini star-coupler. This port provides the serial connection to the other substation with a PC where DIGSI is installed. The protection relays on the remote substation can be interrogated remotely via Port 2. The baud rate is optimally set to 57.6 kbit/s so that no divergence from local operation results. During commissioning and operation, the data of the device in the other substation can be changed and read out. Alternatively, it is possible to connect a substation control system or additional protection data transmission to Port 2. This makes optimum use of the long-distance optical fiber for two independent serial connections for transmitting data between 300 bit/s and 4.096 Mbit/s.

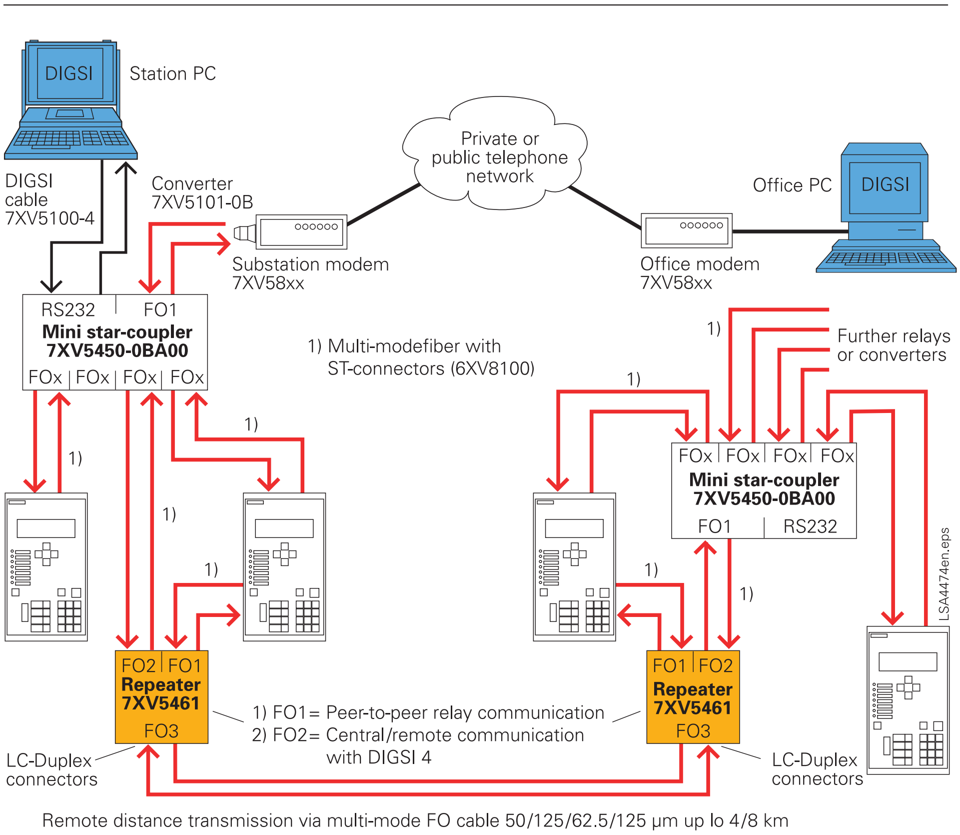


Fig. 14/20
Transfer of protection data and remote control of a substation via an optical long-distance connection

Technical data

Connections	
Ports 1 / 2	ST connector for 820 nm for 50/125 µm and 62.5/125 µm multi-mode FO cable
Port 3	LC-Duplex connector for 1300 nm for 50/125 µm / 62.5/125 µm multi-mode FO cable
Screw-type terminals	2-pole screw-type terminals for auxiliary voltage supply 3-pole make/break contact for alarm relay
Housing	
188 x 56 x 100 mm aluminum housing for mounting on 35 mm DIN rail to EN 50032. Weight 0.8 kg. Degree of protection to EN 60529: IP41	
Power supply	
Wide range 24 to 250 V DC without switchover 115 / 230 V AC	
Displays	
4 LEDs	
Green	Power supply
Red	Alarm relays
2 yellow	Data exchange

14

Selection and ordering data

Description	Order No.
Two-channel serial optical repeater (for multi-mode FO cables)	*7XV5461 - 0B☐00*
Connection of two serial optical inputs with ST connector for 62.5/125 µm multi-mode FO cable up to 1.5 km, from 300 bit/s to 1.5 Mbit/s 24 to 250 V DC, 115/230 V AC wide-range power supply Fault relay and LED for operational and fault display	
Optical 1300 nm output with LC-Duplex connector for 50/125 µm / 62.5/125 µm multi-mode FO cable for distances up to 4 km (permissible path attenuation 13 dB)	*F*
Optical 1300 nm output with LC-Duplex connector for 50/125 µm / 62.5/125 µm multi-mode FO cable for distances up to 8 km (permissible path attenuation 29 dB)	*E*

7XV5550
Active Mini Star-Coupler

Fig. 14/21
Active mini star-coupler

Function overview

One optical input and 4 optical outputs or one RS485 input and 5 optical outputs

- RS232 interface for local access
- RS485 interface for bus structure
- Baud rate and data format can be set independently for each port
- Baud rate 1200 baud – 115 kbaud
- Data format 8N1, 8N2, 8E1
- Max. distance: 1.5 km with 62.5/125 µm multi-mode FO cable
- Light idle state: Light ON/light OFF selectable
- Wide-range power supply with self-supervision function and alarm contact
- Optical ST connectors

Description

Five optical ports allow the active mini star-coupler to centrally or remotely communicate with devices with serial interfaces using different baud rates and data formats. Using a simple ASCII sequence, only one of the available output channels is switched to a transparent full duplex operation. The active mini star-coupler can be used with any terminal program or for SIPROTEC protection relays with the DIGSI operating program. Each of the input and output channels can be parameterized independently to the device attached by adjustable baud rates and data formats or as input or output ports. For communication with more than 5 devices, the active mini star-coupler can be cascaded together with an RS485 bus in half-duplex mode with further devices.

14

Application

Using the integrated optical interfaces of the active mini star-coupler, data transmission for the protection relays V1/2, SIPROTEC 3 or 4 can be performed centrally or remotely with DIGSI. When using the RS485 bus structure each active mini star-coupler provides five optical outputs. An RS232 interface is available for local operation with a notebook. The control PC (directly or via modem) always operates with the same data format, while the interfaces to the different protection relays using other formats are adapted accordingly. For V1/2 protection relays, a 7XV5101-0A plug-in connector module is required for each relay and each relay must be connected to a separate port.

Construction

The active mini star-coupler is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

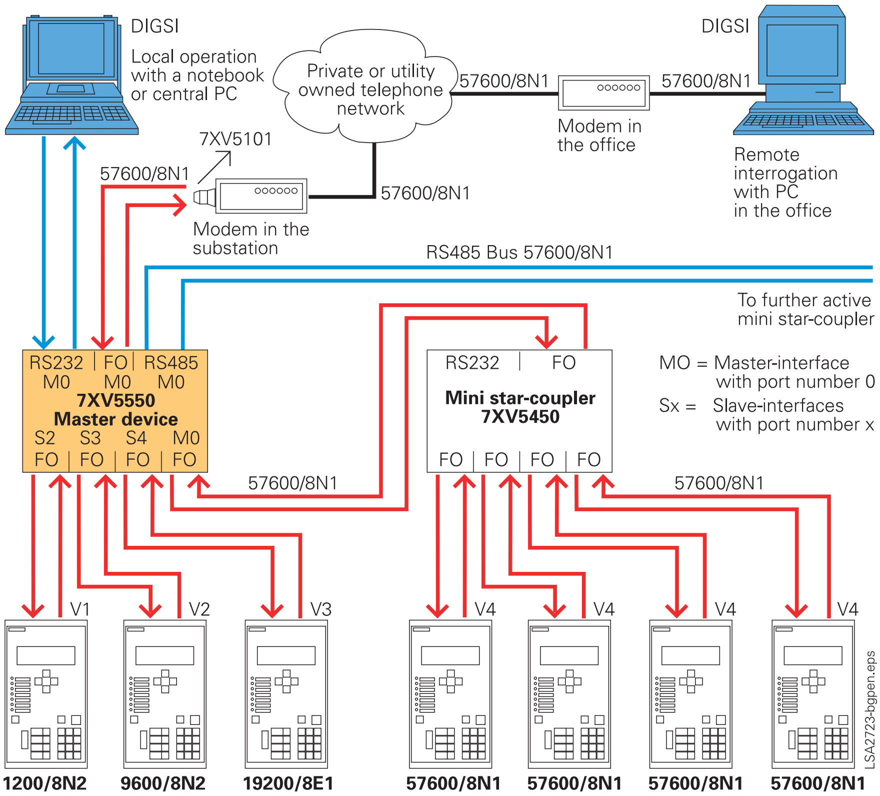


Fig. 14/22

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
LEDs	
3 LEDs Green Yellow Yellow	 Operating voltage o.k. Receiving data Sending data
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO connections	820 nm ST connectors
RS232	9-pin SUB-D socket
RS485	2-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	By jumpers
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting onto 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV5550 active mini star-coupler	*7XV5550-0BA00*

Optical active mini star-coupler with plastic housing for snap-on mounting onto 35 mm rail.

Rated auxiliary voltage 24 - 250 V DC and 110 - 230 V AC with alarm relay.

Connection of up to 4 protection units to an active mini star-coupler via FO cable for 62.5 / 125 µm and 850 nm wavelength, max. distance 1.5 km.

Connection of PC or modem to an active mini star-coupler via FO cable for 62.5 / 125 µm and 850 nm wavelength, max. distance 1.5 km.

Connection also by 9-pin RS232 connector.

Cascadable

Fiber-optic connectors with ST connector

14

7XV5650/5651
RS485 – FO Converter

Fig. 14/23
RS485 – FO converter

Function overview

- Baud rates 9.6 – 115 kbaud
- Topologies:
  7XV5650: Optical star
  7XV5651: Optical line, RS485 bus
- Protocol transparency
- Light idle state:
  Light ON/light OFF selectable
- Distance: 1.5 km with 62.5/125 µm FO cable
- 120 Ω terminator for RS485 bus, activated/deactivated by DIP switch
- Wide-range power supply with self-supervision function and fault output relay

Description

The RS485 – FO converter allows up to 31 devices to be connected with a bus-capable electrical RS485 interface. It provides an optical link-up to a central unit or a star coupler. The converter has been designed for use in substations for interference-free transmission of serial data with rates between 9.6 and 115.2 kbaud by multi-mode FO cable.

The 7XV5651 converter is designed to act as a T-coupler, data can be distributed in a line structure system, forming a basis for building up cost-effective optical bus systems.

The version 7XV5650 is designed for star topology via fiber-optic connection.

Application

The converters can be used in an optical line structure or in an optical star structure. Application in optical line structure allows relays to be connected interference-free via fiber-optic cables; for indoor installation, a cost-effective RS485 bus can be used.

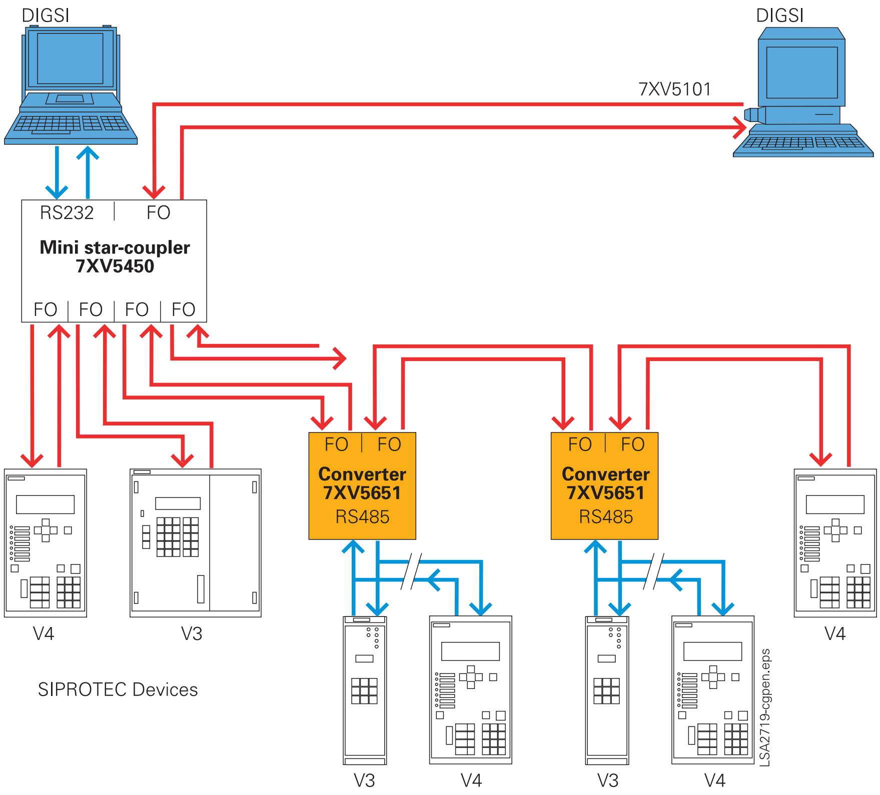


Fig. 14/24 Optical line structure with connected RS485 interfaces

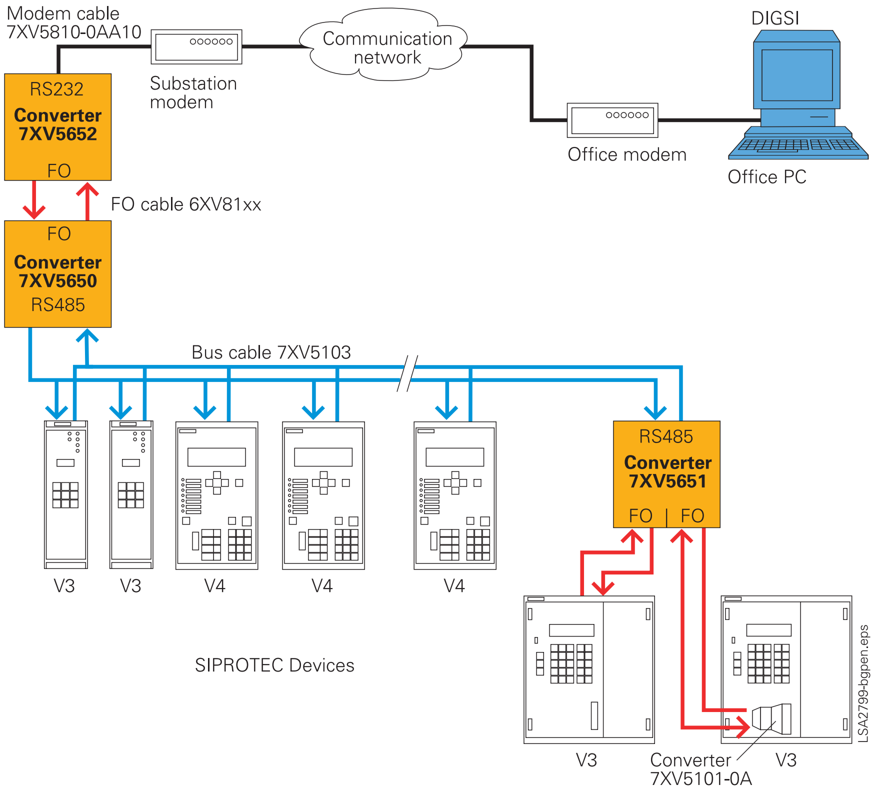


Fig. 14/25 Connection of optical interfaces to an RS485 bus

14

Application

Several units equipped with FO interface and DIGSI or IEC 60870-5-103 protocol can be connected to an existing RS485 bus structure.

Within one system, the data format and the baud rate have to be set to the same values.

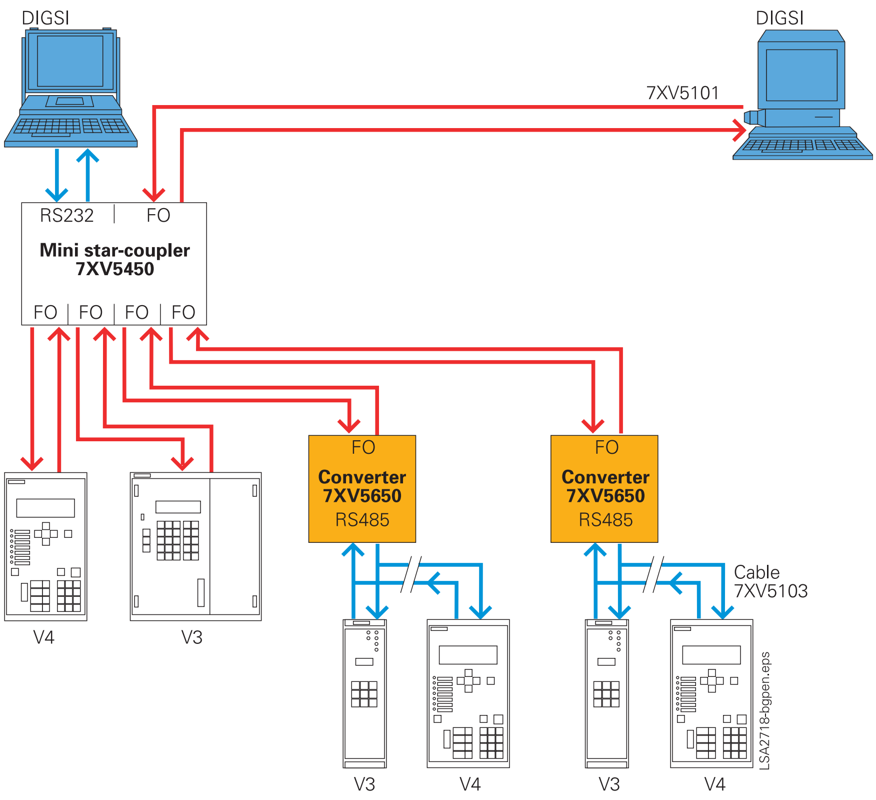


Fig. 14/26 Optical star structure with connected RS485 interfaces

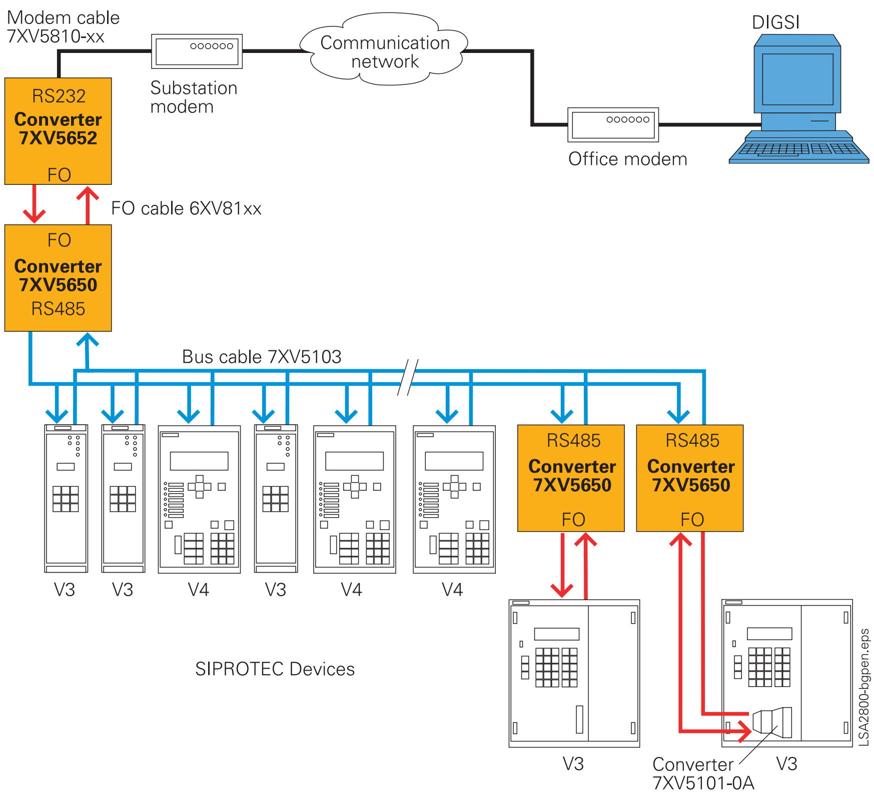


Fig. 14/27 Connection of optical interfaces to an RS485 bus

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals.

The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
Current consumption	
Approx. 0.2 to 0.3 A	
LEDs	
2/3 LEDs	
Green	Operating voltage o.k.
Yellow	Receiving data on FO channel 1
Yellow	Receiving data on FO channel 2 (7XV5651 only)
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO	820 nm ST connector
RS485	9-pin SUB-D socket 2-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting onto 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV565 RS485 – FO converter	*7XV565□-0BA00*
Converter with 1 RS485 interface and 2 FO cables for transmission rates from 9.6 kbaud to 115 kbaud	
With plastic housing for snap-on mounting on 35 mm rail.	
Rated auxiliary voltage 24 - 250 V DC and 110 - 230 V AC with alarm contact.	
Connection of units with RS485 interface by 9-pin SUB-D connector or screw-type terminals.	
Connection of PC or modem to a star coupler via FO cable for 62.5/125 µm or 50/125 µm and 850 nm wavelength.	
Fiber-optic connectors: FO 820 nm with ST connector	
1 channel	0
2 channels	1

14

7XV5652
RS232 – FO Converter

LSP2406-afpde.tif

Fig. 14/28
RS232 – FO converter

Function overview

- Serial baud rates up to 115 kbaud
- No setting of baud rate necessary
- Protocol transparency
- Light idle state: Light ON / light OFF selectable
- Distance: 3 km with 62.5/125 µm FO cable
- Wide-range power supply with self-supervision function and alarm contact
- Supports the serial TxD and RxD lines of the RS232 interface. No handshake lines supported

Description

The RS232 – FO converter is used to convert serial RS232 signals to FO transmission signals in full duplex mode. It has one FO channel for transmission and one for receiving, as well as a protected RS232 interface rated to withstand 2 kV discharges, thus allowing direct connection to the serial system interface of SIPROTEC relays. It is designed to be used in substations for isolated, interference-free transmission of serial signals to a central unit, a star coupler or a PC.

The converter supports the conversion of serial TxD (transmit) and RxD (receive) signals to an optical output. No handshake signals are supported.

14

Application

With the serial RS232 – FO converter, an existing RS232 interface at a SIPROTEC relay can be upgraded to an optical 820 nm interface to connect the relay with further optical components for central and remote interrogation with DIGSI. Another application is the interfacing between a line differential relay and a communication network, which provides electrical RS232 inputs. The connection between the communication room, where the converter is located, and the relay is executed without interference via multi- mode FO cables (Fig. 14/29).

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be connected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.

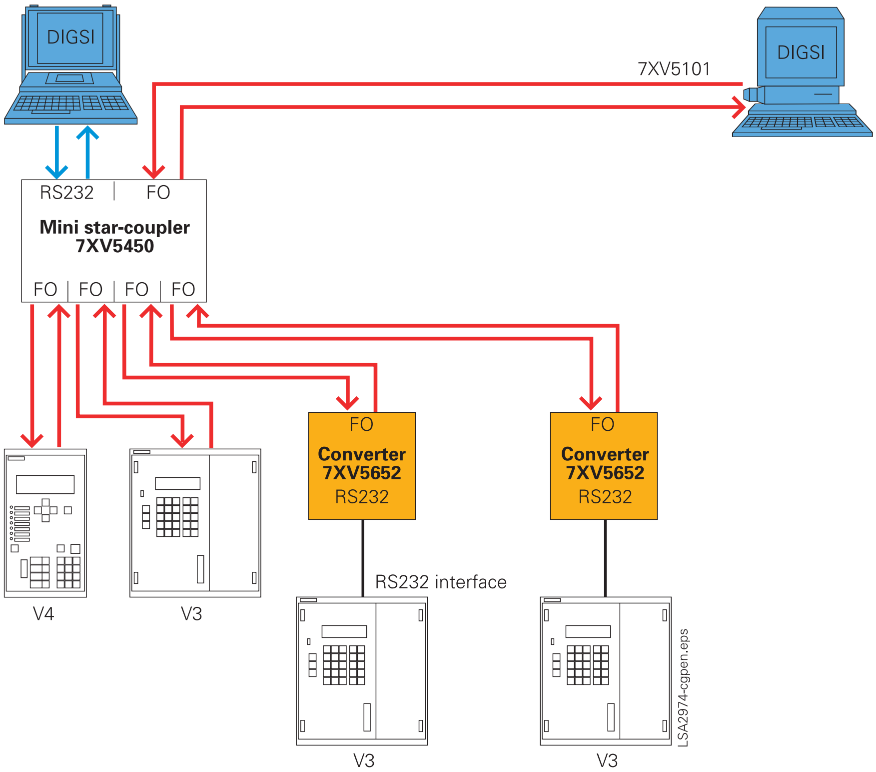


Fig. 14/29 Remote interrogation with the RS232 interface

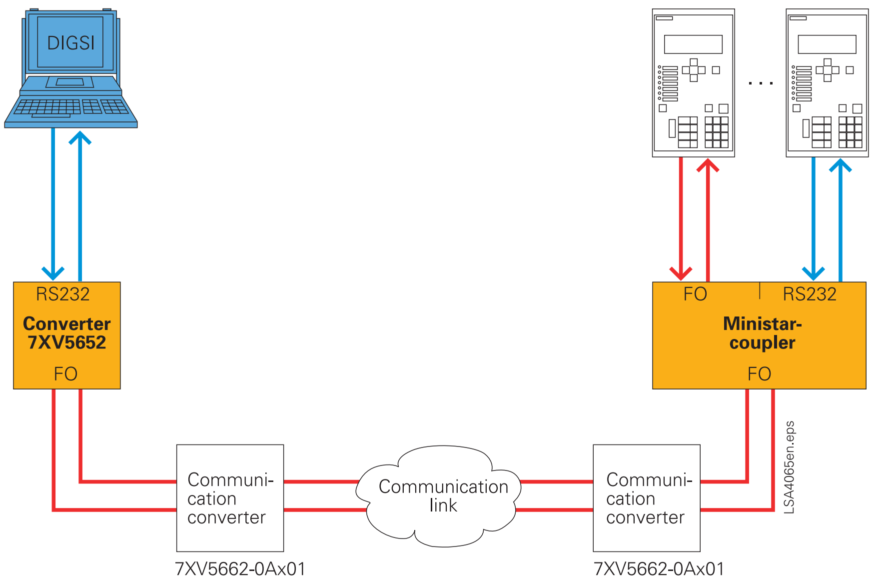


Fig. 14/30 Relay peer-to-peer communication

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
Current consumption	
Approx. 0.1 to 0.2 A	
LEDs	
1 LED Green	Operating voltage o.k.
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO cables	820 nm ST connectors
RS232	9-pin SUB-D socket
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting onto 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV5652 RS232 – FO converter	*7XV5652-0BA00*

For conversion of FO to RS232 (V.24) signals up to 115 kbaud
With plastic housing for snap-on mounting on 35 mm rail
Rated auxiliary voltage 24 - 250 V DC and 110 - 230 V AC with alarm contact.
Connection of units with RS232 interface by 9-pin SUB-D connector
Connection of PC, star coupler, modem via FO cable for 62.5/125 µm and 850 nm wavelength
Fiber-optic connectors: FO 820 nm with ST connector

7XV5653
Two-Channel Binary Transducer

Fig. 14/31
Binary transducer

Description

The transducer registers binary information from contacts via two binary inputs and forwards it interference-free to the second transducer via fiber-optic cable. The indications/signals received by this second transducer are put out via its contacts. The two contacts can be used as trip contacts. The transducer is equipped with independent and bidirectional binary inputs (2) and contact outputs (2).

The transducer has been designed for application in substations. Highly reliable, telegram-backed serial data transmission is used between the transducers. Transmission errors and failure of the data link are indicated via an alarm contact, i.e. a permanent supervision of power supply and the datalink is integrated in the transducer.

Function overview

- 2 isolated binary inputs (24 to 250 V DC)
- 2 isolated trip contacts
- Fast remote trip via a serial point-to-point link of up to 115 kbaud/12 ms.
- Telegram-backed interference-free transmission via FO cable
- Permanent data link supervision and indication
- Distance of approx. 3 km via multi-mode FO cable 62.5/125 µm
- Transmission of up to 100 km via mono-mode FO cable with 7XV5461 repeater
- Transmission via communication networks and leased lines and pilot wires with 7XV5662-0A☐01 communication converters
- Wide-range power supply with self-supervision function and alarm relay

14

Application

The bidirectional transducer registers binary information at two binary inputs and forwards it via fiber-optic cable to a second transducer, which outputs the signals via contacts. Distances of about 3 km can be covered directly via multi-mode fiber-optic cables. The 7XV5461 repeater is available for distances up to 100 km via mono-mode fiber-optic cable. (Fig. 14/32) With two transducers connected to 7XV5461, up to four binary signals can be transferred. One application is phase-selective intertripping.

With a communication converter, the transducer can be interfaced to different kinds of communication links. Modern N x 64 kbit/s digital networks can be used. Existing pilot wires can also be used for data exchange between the relays. The data to be exchanged includes directional signals, intertrip signals and other information.

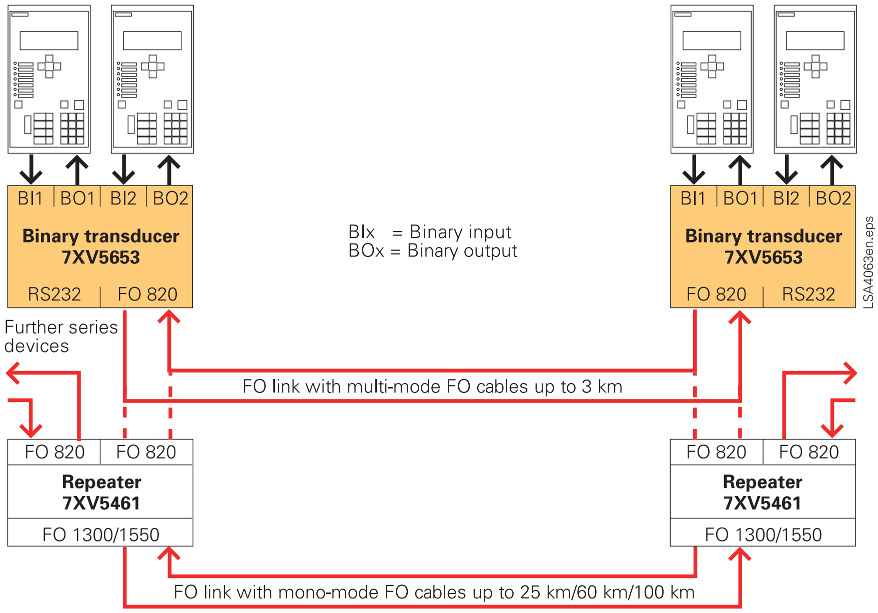
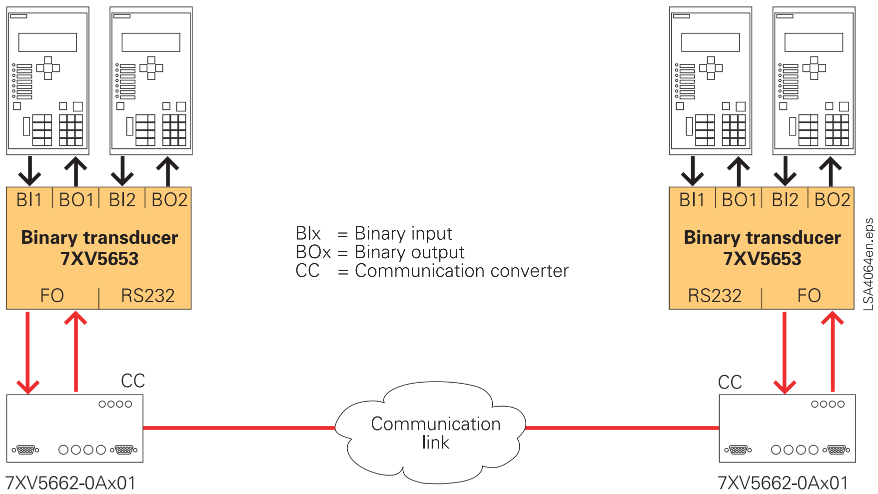


Fig. 14/32

Construction

The converter is provided with a snap-on mounting housing for a 35 mm EN 50022 rail. Auxiliary power supplies can be effected via screw-type terminals. The fiber-optic cables are connected by ST connectors. The unit is free of silicone and halogen as well as flame-retardant.



X = 1: Options for the communication link:
G.703.1, X.21 interface to a communication network
X = 3: pilot-wire cable up to 10 km

Fig. 14/33

Technical data

Rated auxiliary voltage	
24 to 250 V DC and 60 to 230 V AC	± 20 % without switchover
Current consumption	
Approx. 0.15 to 0.25 A	
LEDs	
6 LEDs	
1 x green	Operating voltage o.k.
2 x yellow	Contact unit ½ active
2 x yellow	Command relay ½ active
1 x red	Alarm
Connectors	
Power supply	2-pole Phoenix screw-type terminal
FO connection	820 nm FSMA screw-type connector
FO connection	820 nm ST connector
Binary inputs	4-pole Phoenix screw-type terminal
Alarm contact	2-pole Phoenix screw-type terminal
Light idle state	
Light ON/OFF selectable	
Housing	
Plastic housing, EG90, charcoal grey; 90 x 75 x 105 mm (W x H x D) for snap-on mounting onto 35 mm EN 50022 rail	

Selection and ordering data

Description	Order No.
7XV5653 two-channel binary transducer	*7XV5653-0BA00*

Binary signal transducer

Plastic housing, for snap-on mounting onto 35 mm EN 50022 rail

Rated auxiliary voltage 24 to 250 V DC
and 110 to 230 V AC with alarm relay, 2 binary inputs, 2 trip contacts,
1 alarm relay with potential-free contact for pilot-wire supervision

Connection to a second transducer via FO cable for 62.5 / 125 µm
and 820 nm wavelength (ST connectors). Max. distance 3 km.

Connection to a second transducer via a communication system
with a RS232 interface, 9-pin SUB-D connector, baud rate settable by DIP-switches

Fiber-optic connectors with ST connector

14

7XV5662-0AA00 / 7XV5662-0AA01 Communication Converter for X.21/RS422 and G.703.1

Fig. 14/34
Communication converter for X.21/RS422 and G.703.1

Description

The communication converter for coupling to a communication network is a peripheral device linked to the protection device via fiber-optic cables, which enables serial data exchange between two protection relays. A digital communication network is used. The electrical interfaces in the CC-XG for the access to the communication device are selectable as X.21 (64 kbit/s, 128 kbit/s, 256 kbit/s or 512 kbit/s) or G.703.1 (64 kbit/s). At the opposite side, the data are converted by second communication converter so that they can be read by the second device. The communication converters thus allow two protection devices to communicate synchronously and to exchange large data volumes over large distances. Typical applications are the serial protection interfaces of differential protection and distance protection of the devices 7SD5, 7SD6, 7SA52 and 7SA6, where 7XV5662-0AA00 must be used.

Should asynchronous serial data of differential protection 7SD51 or of the binary signal transducer 7XV5653 be transmitted, the device 7XV5662-0AA01 must be used (asynchronous from 300 bit/s to 115.2 kbit/s dependent on the baudrate set for X.21 or G.703.1 interface). The connection to the protection device is made interference-free by means of a multi-mode fiber-optic cable, with ST connectors at the CC-XG. The maximum optical transmission distance is 1.5 km (0.93 mile).

The data transfer between the protection devices is realized as a point-to-point connection that is bit-transparent. Data must be exchanged via dedicated communication channels, not via switching points.

Function overview

- Optical interface with ST connector for connection to the protection unit
- Distance: 1.5 km with 62.5/125 µm multi-mode FO cable between CC - XG and the protection unit / serial device
- Electrical interface to the communication device via SUB -D connector (X.21, 15 pins, settable to 64, 128, 256 or 512 kbit/s) or with 5-pin screw-type terminals (G.703.1, 64 kbit/s).
- Synchronous data exchange for 7SD52, 7SD6, 7SA6 and 7SA52 protection relays (communications converter version -0AA00)
- Asynchronous data exchange for 7SD51 protection relay, 7XV5653 or other devices with asynchronous interface (communication converter version -0AA01)
- Max. cable length between communication device and communication converter: 100 m for X.21 /RS422
- Max. cable length between communication device and communication converter: 300 m for G.703.1
- Monitoring of:
  - auxiliary supply voltage,
  - clock signal of communication network
  - and internal logic
- Loop test function selectable by jumpers in the CC - XG
- Wide-range power supply unit (PSU) for 24 to 250 V DC and 115 to 250 V AC

Application

The CC - XG can be used for two applications.
One application is the synchronous serial data exchange (converter version - 0AA00) between SIPROTEC 4 differential relays (7SD52, 7SD6) and/or the serial teleprotection between distance relays (7SA6 and 7SA52). The relays have to be equipped with an optical 820 nm plug-in module “FO5”.

Another application is the transmission of asynchronous serial data to the line differential protection relay 7SD51 or the binary signal transmitter 7XV5653.

Functions

The protection unit is optically linked to the CC-XG, which makes interference-free data transfer between the CC - XG and the protection unit possible. The communication converter is located close to the communication device. It adapts the FO active interface of the protection relay to the electrical specifications of the communication network interface. The interface types - optionally X.21 / RS422 or G.703.1 - and the required transmission rate can be set by means of jumpers.

Data transfer between the protection units is effected on the basis of a point-to-point connection, furthermore it is a synchronous, bit-transparent transmission via the communication network.

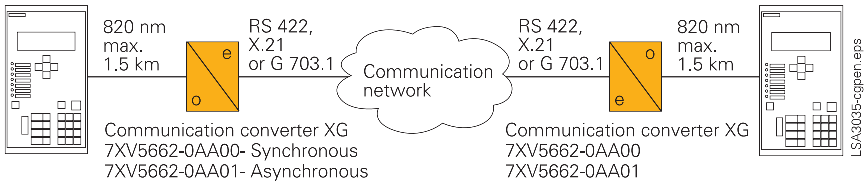


Fig. 14/35 Connection of two protection devices via a communication network linked with 7XV5662-0AA0x

Technical data

Rated auxiliary voltage	
24 to 250 V DC	± 20 %
115/2130 V AC	± 20 % without switchover
Power consumption	Approx. 3.5 W
LEDs	
4 LEDs	
LED 1	Red: Error
LED 2	Yellow: Receiving from X.21/RS422/G.703 interface
LED 3	Yellow: Transmitting to X.21/RS422/G.703 interface
LED 5	Green: Operating voltage o.k.
Connectors	
Power supply	2-pole screw-type terminal
Alarm/ready contact	3-pole make/break contact
Serial G.703.1 interface	5-pole receive and transmit line
SUB-D connector	15-pin SUB-D connector for electrical X.21/RS422 interface
FO cable	820 nm, 2 ST connectors for TxD and RxD for 62.5/125 µm multi-mode FO (max. distance to protection unit 1.5 km)
Housing	
Aluminium die-cast housing	Dimensions 188 x 56 x 120 mm (WxHxD)
Weight	Approx. 0.8 kg
Degree of protection	According to EN 60529: IP 41
For snap-on mounting onto 35 mm	EN 50022 rail

14

Technical data

Operating mode		
Synchronous operation with	7XV5662-0AA00 for 7SD52, 7SD6, 7SA52 and 7SA6	
	G.703.1: Interface selectable by jumper X30 in position 2 - 3	
	Setting in the protection unit	Setting in CC-XG by jumper
	64 kbit/s per parameter	64 kbit/s by jumper X20 = 1
	X.21/RS422: Interface selectable by jumper X30 in position 1 - 2	
	Setting in the protection unit	Setting in CC-XG by jumper:
	64 kbit/s per parameter	64 kbit/s by jumper X20 = 1
	128 kbit/s per parameter	128 kbit/s by jumper X22 = 1
	256 kbit/s per parameter	256 kbit/s by jumper X24 = 1
	512 kbit/s per parameter	256 kbit/s by jumper X26 = 1
Asynchronous operation with	7XV5662-0AA01 for 7SD51, 7XV5653 and units with asynchronous serial interface (no handshake supported, only serial TxD and RxD signals are supported)	
	G.703.1: Interface selectable by jumper X30 in position 2 - 3	
	Setting in protection unit	Setting in CC-XG by jumper
	max. 19.2 kbit/s	64 kbit/s by jumper X20 = 1
	X.21/RS422: Interface settable by jumper X30 in position 1 - 2	
	Setting in protection unit	Setting in CC-XG by jumper
	max. 19.2 kbit/s async.	64 kbit/s by jumper X20 = 1
	max. 38.4 kbit/s async.	128 kbit/s by jumper X22 = 1
	max. 57.6 kbit/s async.	256 kbit/s by jumper X24 = 1
	max. 115.2 kbit/s async.	512 kbit/s by jumper X26 = 1

Selection and ordering data

Description	Order No.
Communication converter for X.21/RS422/G.703.1 interface	*7XV5662 - 0AA0☐*
Converter to synchronous or asynchronous serial coupling of protection units with optical inputs/outputs with ST connector to communication devices with electrical X.21/RS422 or G.703.1 interface. Connection to protection unit via FO cable for 62.5/125 µm and 820 nm wavelength, max. distance 1.5 km, ST connectors Electrical with X.21/RS422 (15-pin SUB-D connector) or G.703.1 (screw-type terminal) Baud rate and interface type selectable by jumpers	
For synchronous operation with 7SD52, 7SD6, 7SA6, 7SA52	*0*
For asynchronous operation with 7SD51, 7XV5653 or serial devices	*1*

14

7XV5662-0AC00/7XV5662-0AC01 Communication Converter for Pilot Wires

Fig. 14/36
Communication converter for pilot wires

Description

The communication converter copper (CC-CO) is a peripheral device linked to the protection device which enables serial data exchange between two protection relays. It uses a single pair of copper wires (pilot wire) that may be part of a telecommunications cable or of any other suitable symmetrical communications cable (no Pupin cable). At the opposite side, the data are converted by a second communication converter so that they can be read by the second protection device. The communication converters (master/slave) thus allow two protection devices to communicate synchronously and to exchange large data volumes over considerable distances. Typical applications are the protection interfaces of differential protection and distance protection of the devices 7SD5, 7SD6, 7SA52 and 7SA6, where 7XV5662-0AC00 must be used (synchronous connection with 128 kbit/s). Should asynchronous serial data of differential protection 7SD5 or of the binary signal transducer 7XV5653 be transmitted, the device 7XV5662-0AC01 must be used (asynchronous from 300 bit/s to 38.2 kbit/s).

The connection to the protection device is made interference-free by means of a multi-mode fiber-optic cable, with ST connectors at the CC-CO. The maximum optical transmission distance is 1.5 km (0.93 mile). The data transfer between the protection devices is realized as a point-to-point connection that is bit-transparent. Data must be exchanged via dedicated pilot wires, not via switching points.

Function overview

- Optical interface with ST connector for connection to the protection unit
- Distance: 1.5 km with 62.5/125 µm multi-mode FO cable between CC - CO and the protection unit
- Electrical interface to the pilot wire (line) with 2 screw-type terminals. 5 kV isolated
- Synchronous data exchange for 7SD52, 7SD6, 7SA6 and 7SA52 via pilot wire (typ. 15 km) (CC - CO version -0AA00)
- Asynchronous data exchange for 7SD51, 7XV5653 or other units with asynchronous interface (CC - CO version -0AA01) (typ. 15 km)
- Loop test function selectable by jumpers in CC - CO
- Master or slave mode of the CC - CO selectable by jumper (one master and one slave device required at the end of the pilot wire, factory presetting: master mode)
- Wide-range power supply with self-supervision function and alarm contact

Application

The CC - CO can be used for two applications.
One application is the synchronous serial data exchange (converter version - 0AA00) between SIPROTEC 4 differential relays (7SD52, 7SD6) and/or the serial teleprotection between distance relays (7SA6 and 7SA52). The relays have to be equipped with an optical 820 nm plug-in module "FO5".

Another application is the transmission of asynchronous serial data via pilot wires to the line differential protection relay 7SD51 or the binary signal transmitter 7XV5653. Other serial devices may also be used.

If the maximum distance between the protection units is longer than spanned by two CC-CO, the converters can be cascaded (see Fig. 14/38). A power supply between the two master units is required.
If the isolation level is higher than 5 kV (provided by the pilot wire inputs of the units), external isolation transformers (barrier transformers) can be used on both sides. These transformer offer 20 kV isolation voltage and thus help to avoid hazardous high voltages at the inputs of the CC-CO, which might be induced by a short-circuit from a parallel power line or cable.

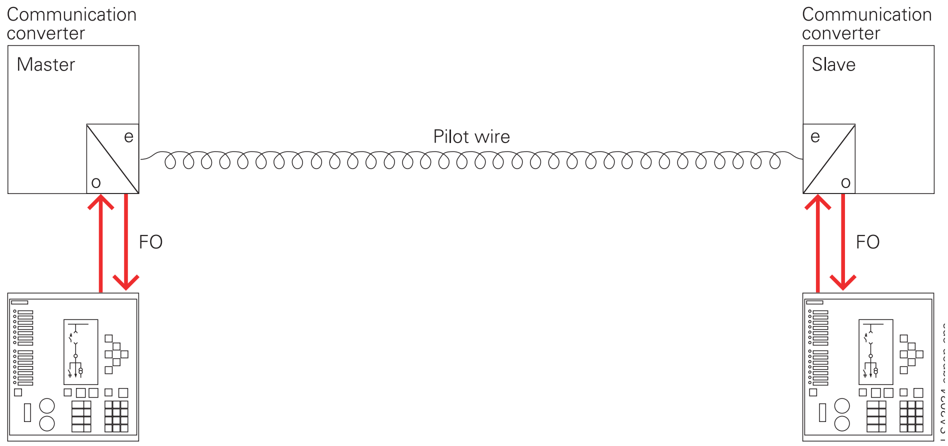


Fig. 14/37

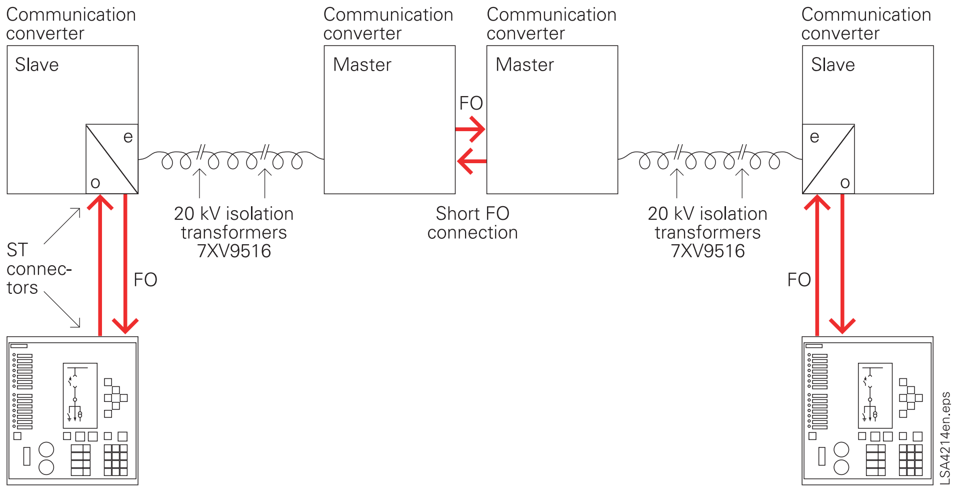


Fig. 14/38

Functions

The protection unit is optically linked to the CC-CO, which makes interference-free data transfer between the CC - CO and the protection unit possible. The communication converter is located close to the pilot wire. It converts serial data of the protection unit into a frequency-modulated signal. This signal is transmitted via one pair of copper wires of a pilot wire/communication line (bi-directional, full duplex operation).

By means of jumpers, one unit is defined as "master" and the other unit as "slave". In a "training" during commissioning, the electrical characteristics of the pilot wire are measured by pressing a pushbutton, and the CC - COs are tuned to these characteristics.

The measured characteristics are used as parameters that will be adhered to for optimal data transfer. Digital data transfer makes a low insulation level of the pilot wire possible, because no high voltages are produced on the pilot wire during short-circuit conditions.

Data transfer between the protection units is effected on the basis of a point-to-point connection, furthermore it is a synchronous, bit-transparent transmission. Due to the telegram-backed data exchange, mal-operation is ruled out.

Technical data

Rated auxiliary voltage	
24 to 250 V DC	± 20 %
115/230 V AC	± 20 % without switchover
LEDs	
4 LEDs	
LED 1	Red: Line activation
LED 2	Yellow: Line transparent
LED 3	Yellow: Data transfer
LED 5	Green: Power ON
Connectors	
Power supply	2-pole screw-type terminal
Alarm/ready contact	3-pole make/break contact
Pilot wire	2-pole for pilot-wire connection 5-kV isolated inputs
FO cable	820 nm, 2 ST connectors for TxD and RxD for 62.5/125 µm multi-mode FO (max. distance to protection unit 1.5 km)
Pushbutton	
Measuring and training of parameters of the pilot wire	
Housing	
Aluminum die-cast housing	Dimensions 188 x 56 x 120 mm (WxHxD)
Weight	Approx. 0.8 kg
Degree of protection	According to EN 60529: IP 41
For snap-on mounting onto 35 mm	EN 50022 rail
Operating mode	
Synchronous operation with	7XV5662-0AC00 for 7SD52, 7SD6, 75A52 and 7SA6 Setting in the protection unit: 128 kbit/s per parameter Setting in CC - CO: 128 kbit/s. No setting required
Asynchronous operation with	7XV5662-0AC01 for 7SD51, 7XV5653 and units with asynchronous serial interface (no handshake supported, only serial TxD and RxD signals are supported) Max. baud rate for protection unit: 38.4 kbit/s Max. baud rate for CC - CO 128 kbit/s. No setting required
Max. distance with pilot wire	AWG 16 / 1.3 mm^2 / 13 Ω/km: max. 40 km AWG 18 / 0.82 mm^2 / 21.9 Ω/km: max. 27 km AWG 20 / 0.5 mm^2 / 34.1 Ω/km: max. 18 km AWG 22 / 0.33 mm^2 / 51.7 Ω/km: max. 11 km AWG 26 / 0.13 mm^2 / 137 Ω/km: max. 4.5 km
	Shielded twisted pair (STP) recommended. Max. loop resistance: 1400 Ω Attenuation < 40 dB at 80 kHz

Selection and ordering data

Description	Order No.
Communication converter for pilot wires	*7XV5662 - 0AC0□*
Converter for synchronous or asynchronous serial coupling of protection units with optical inputs/outputs with ST connector to conventional pilot wires. 5-kV isolation of unit analog inputs towards the pilot wires. Connection to protection unit via FO cable for 62.5/125 µm and 820 nm wavelength, max. distance 1.5 km, ST connectors Synchronous serial data 128 kbit/s Asynchronous serial data rate max. 57.2 kbit/s	
For synchronous operation with 7SD52, 7SD6, 7SA6, 7SA52	*0*
For asynchronous operation with 7SD51, 7XV5653 for other units	*1*

14

14

7XV5662-□AD10 Temperature Monitoring Box

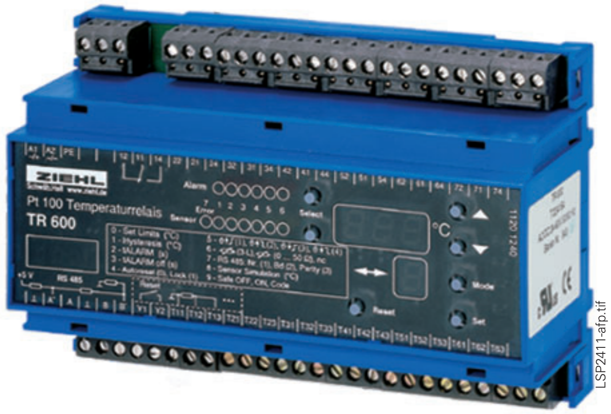


Fig. 14/39
Temperature monitoring box

Description

The temperature monitoring box (also called RTD-unit(resistance temperature detector) or thermo-box) can be used together with the 7UT6, 7UM62 and 7SJ6 relays for thermal monitoring of machines and transformers. It is connected via its serial RS485 interface to the RS485 interface of the SIPROTEC 4 units. External opto-electrical converters (7XV5650 / 7XV5651), however, allow the RTD unit to be connected to the optical 820-nm interface of the protection relay (Port C or Port D). Measurement of 6 temperature values is effected by Pt100 (recommended), Ni100 or Ni200 sensors and transmitted by telegrams to the SIPROTEC relay. The relay displays the measured values, monitors them and generates alarms when previously parameterized limiting values are exceeded. For 7UT6 with its extensive transformer monitoring functions, special functions like hot-spot calculation are available. Wiring to the sensors and wire breakage are monitored as well. Two boxes with a maximum of 12 sensors (this corresponds to 12 measuring locations) can be connected to one SIPROTEC relay.

Function overview

- Measurement and display of 6 temperatures with Pt100, Ni100 or Ni120 sensors per box. With two boxes: a total of 12 measurements.
- Connection of up to 2 boxes via the RS485 interface of the relay. Optical connection can be established with additional converters (7XV5650 / 7XV5651)
- 2- or 3-wire connection of thermal sensors is supported (3-wire connection recommended)
- Monitoring of each sensor wiring and alarm in case of wire breakage. Alarm is indicated in the box itself and in the relay monitoring function.
- Measuring range of temperature for Pt100: -100 °C to +800 °C

14

Application

A maximum of two RTD units can be connected to a protection relay. These units offer up to 12 RTD inputs, which can be monitored by the RTD function in the relay or supervised by a user-defined logic in the relay, where user-defined alarms can be generated. The connection (up to 1000 m) between the RTD unit and the relay can be made by an RS 485 - electrical bus. For distributed RTD units or fully interference-free connections, FO connections are recommended. Fig. 14/41 illustrates the application with FO cables and 7XV5651 converters. If only one RTD unit is connected to the relay it is sufficient to have one FO connection from the 7XV565x converter to the relay.

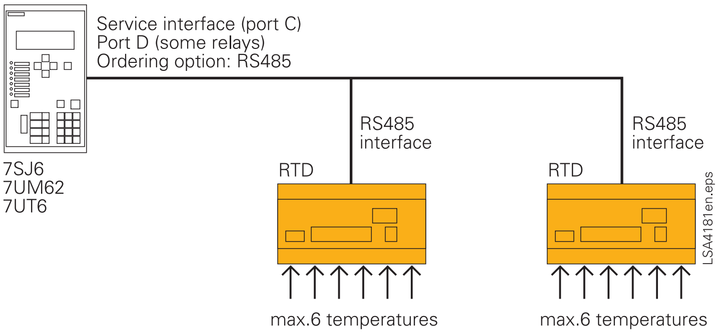


Fig. 14/40
Connection of two RTD units to a protection unit via RS485 bus

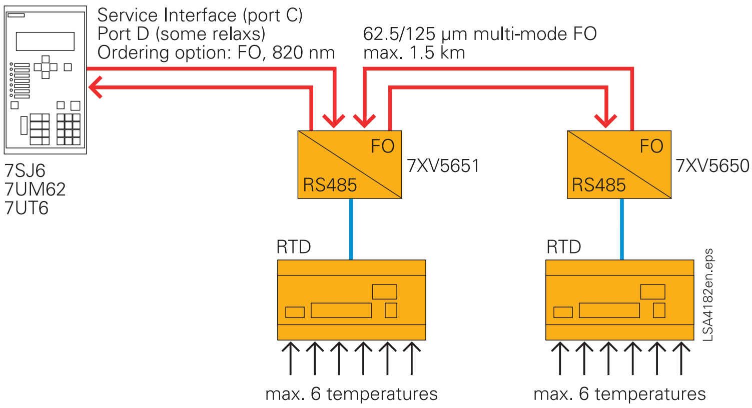


Fig. 14/41
Optical connection of two RTD units to a protection unit

Technical data

Rated auxiliary voltage	
for 7XV5662-2AD10	24 to 60 V AC/DC
Tolerance DC-supply	20 to 81 V DC (0.85 x 24 V...1.35 x 60 V)
Tolerance AC-supply	20 to 66 V AC (0.85 x 24 V...1.1 x 60 V)
Auxiliary voltage	
for 7XV5662-5AD10	90 to 240 V AC/DC
Tolerance DC-supply	81 to 297 V DC (0.9 x 90 V...1.35 x 220 V)
Tolerance AC-supply	76 to 264 V AC (0.85 x 90 V...1.1 x 240 V)
Power consumption	< 8 VA
Frequency	0 / 50 / 60 Hz
Relay output	
Number	1 changeover (CO) contact
Switching voltage max.	415 V AC
Switching current	max. 5 A
Switching power cos φ = 1 (PF)	max. 1250 V A (ohmic load) max. 48 W at 24 V DC
Derating factor	PF = 0.7/0.5
U_L electrical ratings	3 A resistive, 240 V AC C300/Q300
Sensor connection	
Number	6 x Pt100 acc. to DIN 43760 /IEC 60751
Measuring accuracy	± 0.5 % of value ± 1 digit
Sensor current	< 2 mA
3-wire sensor	Pt100 + R_L = max. 490 Ω
2-wire sensor	R_L = 0...50.6 Ω adjustable
Measuring delay time	
Time	t_M < 1.5 s (normal operation, depends on number of connected sensors)
Switch points	
Number	6, numerically adjustable
Relay operating function	Standard = closed circuit current principle (NC) Option = operating current (NO)
Temperature alarm	
Temperature range 1 … 6	- 199 to + 800 °C
Hysteresis	1 to 20 K
Release delay time t_{ALARM}	0.1 to 99.9 s
Pickup delay time $t_{ALARM\ off}$	0 to 999 s

Max. ambient temperature	
Operating temperature	- 20 to + 65 °C
UL 508 ambient temperature	- 20 to + 55 °C
Storage temperature	- 20 to + 70 °C no condensation permitted
RS485 interface	
Address of unit	0 to 99
Baud rate	4800, 9600, 19200 Baud
Parity	N, O, E (no, uneven, even)
Housing	
Type	V8
Dimensions (W x H x D)	140 x 90 x 58 mm
Line connection solid wire	each 1 x 1.5 mm^2
Stranded wire with insulated connector end sleeve	each 1 x 1.0 mm^2
Torque	0.5 Nm (3.6 lb.in)
Protection class of housing	IP31
Protection class of terminals	IP20
Mounting	Snap-on mounting onto 35 mm EN 50022 rail or M4 screws
Weight	Approx. 350 gr

Selection and ordering data

Description	Order No.
Temperature monitoring box	*7XV5662 - ☐AD10*
Measurement of up to 6 temperatures for 7UT6, 7SJ6 or 7UM62 with Pt100, Ni100 or Ni120 sensors (Pt100 recommended), With serial RS485 interface	
Power supply range (24 - 60 V AC/DC)	2
Power supply range (90 - 240 V AC/DC)	5

7XV5664 / 7XV5654 GPS/DCF77 Time Synchronization System

7XV5664 time signal receiver

7XV5654 time synchronization unit (sync.-transceiver)

Fig. 14/42
GPS/DFC77 time synchronization system

Description

The 7XV5664 GPS/DCF77 time signal receiver (TSR) is part of the time synchronization system for all SIPROTEC 4 units. It is equipped with an antenna and a 25-m screened cable. The other devices of the time synchronization system are the 7XV5450 mini star-coupler (optional) and the 7XV5654-0BA00 time synchronization unit (sync.-transceiver).
A user-friendly software package for PC (included in the scope of delivery) facilitates configuration of the receiver via an RS232 interface.

The optical outputs provide interference-free transmission of the time signals to the relays. Close to the relays, the sync.-transceiver 7XV5654 converts these optical signals to electrical signals. These signals are input signals for Port A of SIPROTEC 4 units or for binary inputs, which can also be used for time synchronization.

Function overview

- An optical output with ST connector is provided for potential and interference-free direct transmission of DCF77 or IRIG-B time synchronization telegrams to the SIPROTEC 4 units. There they are converted to an electrical signal by a 7XV5654-0BA00 time synchronization unit and injected via the time synchronization interface of the SIPROTEC 4 units (Port A) (see Fig. 14/43)
- On a second optical output, a high-precision minute or second pulse can be issued with microsecond accuracy.
- With this minute pulse, the SIPROTEC 4 unit internal clock can be synchronized via a binary input. The opto-electrical converter 7XV5654-0BA00 supports this process.
- A special application of the pulse-per-second function is the highly accurate synchronization of 7SD52 differential protection unit versions that feature the GPS synchronization function. This facilitates the exact detection of the transfer time of telegrams between the units in both the transmit (send) and the receive direction.
- The receiver requires 24 V DC power supply. Other auxiliary voltages may be converted to 24 V DC by the DC/DC converter 7XV5810-0BA00.

Application

The GPS/DCF77 TSR is installed close to the aerial (max. distance 25 m). Auxiliary voltage is supplied by the 7XV5810-0BA00 wide-range power supply unit from the AC system or a substation battery. The interference-free transmission of the time telegrams or synchronization pulses is effected via a fiber-optic cable to the sync. -transceivers which are located close to the relay. With the mini star-coupler 7XV5450, these signals can be transmitted to further sync.-transceivers, if required.
A 7XV5664-0BA00 sync.- transceiver is used to convert the optical signals to 24-V electrical signals for the time synchronization interface (Port A) of the SIPROTEC 4 unit. For every six SIPROTEC 4 units, one sync.- transceiver is required. On the second optical output, a minute pulse can be issued to the relays. The 7XV5654 converts the optical pulses to electrical pulses for a binary input of the relay. The connection of the sync.-transceiver to the protection units is established with an adaptor cable and two 7XV5104 Y-bus cables (see Fig. 14/43)

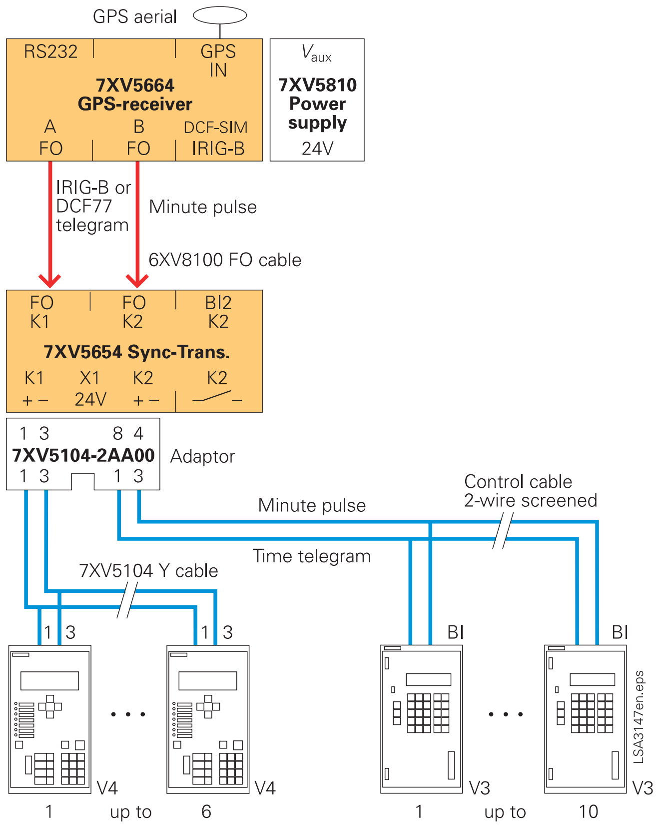


Fig. 14/43 SIPROTEC 4 protection unit with GPS-time synchronization

Selection and ordering data

Description	Order No.
GPS-time signal receiver for time synchronization of all SIPROTEC 4 units with aerial, 25 m coaxial cable, PC software with cable (without wide-range power supply unit 7XV5810-0BA00) Device in standard industrial housing for DIN-rail mounting 2 optical ST connectors. 24 V DC power supply voltage	*7XV5664-0AA00*
Time synchronization unit (sync.-transceiver) Sync.-transceiver for conversion of 2 optical time signals to 24 V/battery voltage for the time synchronizing interface of SIPROTEC 4 units (Port A) / or binary input 2 optical ST connectors. Wide range power supply. Alarm contact.	*7XV5654-0BA00*
Y-bus cable	*7XV5104-0AA□□*
Y-bus cable 2-wire shielded with 9-pin SUB-D connector and metal housing for the clock synchronization of SIPROTEC 4 units	
Length 1 m	*0 1*
Length 3 m	*0 3*
Length 5 m	*0 5*
Length 10 m	*1 0*
Note: Extension cables 7XV5104-1AAxx in 10, 20, 30, 40, 50 m available	
Adaptor cable Adaptor cable 2-wire shielded with cable lugs to 9-pin SUB-D connector (female) for connection of the Y-cable to the sync.-transceiver 7XV5654-0BA00	*7XV5104-2AA00*

7XV57
RS232 – RS485 Converter


LSP2027-afp.tif

Fig. 14/44
RS232 – RS485 converter

Function overview

- Minimum baud rate: 9600 baud
- Maximum baud rate: 115 kbaud
- No setting of baud rate necessary
- Compact plug casing
- Power supply via plug in PSU
- Maximum 31 relays at RS485 bus
- Complete set for connecting 1 relay to RS485 bus

Description

Up to 31 SIPROTEC 4 relays with an electrical, bus-capable RS485 interface to a PC for centralized control can be connected via the RS232↔RS485 converter.

The converter is housed in an expanded plug casing. The interfaces are connected to 25-pin female connectors. The auxiliary voltage is supplied via a plug-in power supply unit attached to the side. Auxiliary voltages of 110 or 230 V AC make operation with all common AC networks possible.

A twisted and shielded cable with two wires is required for the RS485 bus. The protection relays are connected to the bus in series. Data transmission at a speed of 19.2 kbaud with a bus length of up to approximately 1000 m is possible.

The converter, plug-in power supply unit and the connecting cable to the first relay are included in the scope of supply.

Applications

The RS232↔RS485 converter allows up to 31 SIPROTEC 4 protection relays with electrical busable RS485 interfaces to be connected to a PC notebook.

The converter is housed in an expanded plug casing. The interfaces are connected to 25 pin female connectors. The RS485 interface has a terminating resistor. The auxiliary voltage is supplied via a plug-in power supply unit attached to the side. Auxiliary voltages of 110 V or 230 V AC make operation with all common AC networks possible.

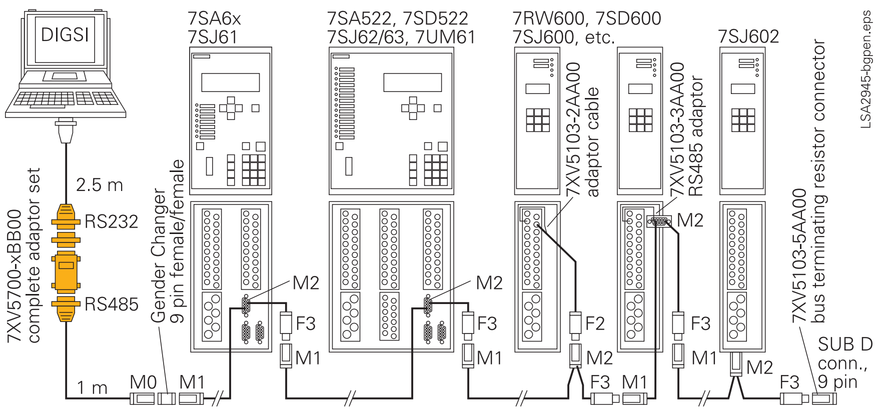


Fig. 14/45 Protection units connected to the RS485 bus

Note
The converter may not be used with a substation modem due to non-existing isolation. It is recommended to use the 7XV5650 and 7XV5651 converters in conjunction with the substation modem.

Functions

The converter works according to the master/slave principle. In idle state, the RS232 interface is inactive while the RS485 interface is switched to the receiving mode. During communication, the PC (master) sends data to the RS232 interface, which are transmitted (half duplex) to the protection unit (slave) by the converter at the RS485 interface. After data transmission, the RS485 interface is once again switched to the receiving mode. Vice versa, data supplied by the protection unit are sent back by the converter to the RS232 interface and to the PC.

No handshake signals are being processed during communication. This means that data sent by the PC are mirrored, which may cause problems in special applications.

Connections

The PC is connected to the converter by means of a DIGSI cable e.g. 7XV5100-2.

A twisted and shielded cable with two wires is required for the RS485 bus. The conductor cross section has to be adapted to the ring cable lugs and the SUB-D connectors. The individual wires protruding from the shield should be kept as short as possible. The shield is connected to the housing earth at both ends. The protection units are connected in series to the bus. The shield between the converter and the protection units, or between the protection units, is connected at both sides. Whenever substantial cable lengths or high baud rates are involved, a terminating resistor of 220 ohm should be applied between signal lines A and B at the last protection unit. Data transmission at a speed of 19.2 kbaud, with a bus length of up to approx. 1000 m, is possible.

Technical data

Design	
Plug chassis	Plastics
Dimensions	63 x 94 x 16 mm (W x H x D)
Degree of protection	IP 20
Power supply	
Power supply	110 or 230 V AC
Via	Plug-in power supply unit
Electrical interfaces	
Type	RS232 to RS485 (non-isolated)
Assignment	See Fig. 14/45
CE conformity, standards	
This product is in conformity with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to the electromagnetic compatibility (EMC Council Directive 89/336/EEC).	Conformity is proved by tests performed by Siemens AG in accordance with the generic standards EN 50081-1 and EN 50082-2.

Selection and ordering data

Description	Order No.
7XV5700 RS232 – RS485 converter	*7XV5700-□□□00*
Rated auxiliary voltage	
Via plug-in auxiliary power supply unit (PSU) 230 V / 50 Hz AC	*0*
Via plug-in auxiliary PSU 110 V / 60 Hz AC	*1*
Connecting cable	
With RS485 connecting cable for 7SJ60, 7RW60, 7SD6, 7SV60, length 1 m	*A*
With RS485 connecting cable for SIMEAS Q and SIPROTEC 4, length 1 m	*B*
With RS485 connecting cable for SIMEAS T, length 1 m	*C*
Without RS232 connecting cable	*A*
With RS232 connecting cable 7XV5100-2 for PC/notebook, 9 pin	*B*
With RS232 adaptor, 25-pin connector (male) to 9-pin connector (female) for PC / notebook	*C*

14

7XV5800
Industrial Modems

Fig. 14/46
7XV5800 industrial modem

Function overview

- Synchronous and asynchronous support
- Dial-up and 2-wire leased line support
- 4-wire leased line support and dial backup on some models
- Remote configuration for centralized set-up and management
- Phone number storage for automatic or DTR dialing
- Flash memory for easy updates
- Data transmission, fax, and other value-added software
- Auxiliary voltage supply via power supply unit 230 V AC

Description

The full-featured MultiModem II modem range for industrial application provides high-speed and reliable data and fax communication. It is housed in a robust metal case. This modem range is ideally suited for applications in control systems and substations in the power transmission and distribution sector. It supports the data frame 8E1, which is used for the IEC ....- 103 and DIGSI protocols, if a parity bit should be transmitted.

For the current modem versions, please consult our download area on the Internet: www.siprotec.com “Accessories”

Application

It is highly recommended to use the modems described below for any communication application mentioned in this catalog.

33.6K Model MT2834 desk top unit

- V.34 / 33.6 K
- Expanded Class 2 faxing at 14.4 K
- Synchronous and asynchronous support
- Password-protected, fixed and variable call-back security
- 11-bit application support (IEC protocol)
- Multi-Tech AT command set
- AS/400® settings, UUCP spoofing
- External sync clock support

56K Model MT5600 desk top unit

- V.90 / K56flex™
- Class 1 and Class 2 faxing at 14.4 K
- LCD panel for easy configuration and diagnostics

56K Model MT5634 (PCMCIA) for Notebooks

- PCMCIA Standard V.90 / K56flex™
- Class 1 and Class 2 faxing at 14.4 K
- Global model for worldwide use
- "Plug and Play" operation

Selection and ordering data

Description	Order No.
7XV5800 industrial modem desktop unit in metal housing with power supply unit, 230 V AC	*7XV5800-□□□00*
MT2834 V.34 / 33.6 K with 10 / 11 bit (8E1) call-back security	*2*
MT5600 V.90/56 K with 10 bit (8N1) call-back security	*3*
Region TYPE INTL Europe / rest of the world	*B*
Operating modes TYPE BA dial-up and 2-wire leased line support[1)]	*A*
Modem for Notebooks	*7XV5800-7AA00*
MT5634 ZLXI PCMCIA Type II MultiMobile modem V.90 / 56 K with 10 bit (8N1), for worldwide use	

1) The 7XV5662-0AC01 communication converter can be used for 2-wire leased line support up to 10 km.

7XV5655-0BB00
Ethernet Modem

Fig. 14/47
Front view of the Ethernet modem

Function overview

- RS232 interface for data transfer and configuration of the modems
- Serial baud rate and data format (RS232/RS485) for the terminal devices is selectable from 2400 Bd up to 57.6 kBd with data format 8N1, 8E1
- FO interface for serial data transfer
- 10 Mbit Ethernet interface (LAN) to the 10/100 Mbit Ethernet network
- Increased security with password protection and IP address selection is possible
- Exchange of serial data via Ethernet network between two Ethernet modems (e.g. DIGSI protocol, IEC 60870-5-103 protocol)
- Exchange of serial protocols via Ethenet without gaps in the telegram structure

Description

A control PC and protection relays can exchange serial data via an Ethernet network using two Ethernet modems 7XV5655. Connection to the Ethernet modem is in each case made via the asynchronous serial interface of the terminal devices. In the modem the serial data is packed into the secure IP protocol as information data, and is transferred between the modems using the Ethernet connection. Conformity with the standard and gap-free transmission of serial DIGSI or IEC 60870-5-103/101 telegrams (frames) via the network is ensured by the modem which receives the serial telegram communication and packs the serial IEC telegrams into blocks for communication via the Ethernet. Data is transmitted in full duplex mode, the serial handshake is not supported. The connection is set up between the IP address of the dialing modem in the office and the IP address of the answering modem in the substation and is configured prior to dial up with DIGSI by means of AT commands via the RS232 interface.

The substation modem may be configured to have password protection, and provides the additional security feature, permitting access only from defined IP addresses, e.g. only that of the office modem. The modem is accessed with DIGSI Remote like a normal telephone modem with the exception that instead of telephone numbers, IP addresses are assigned by the network administrator for each modem.

Application

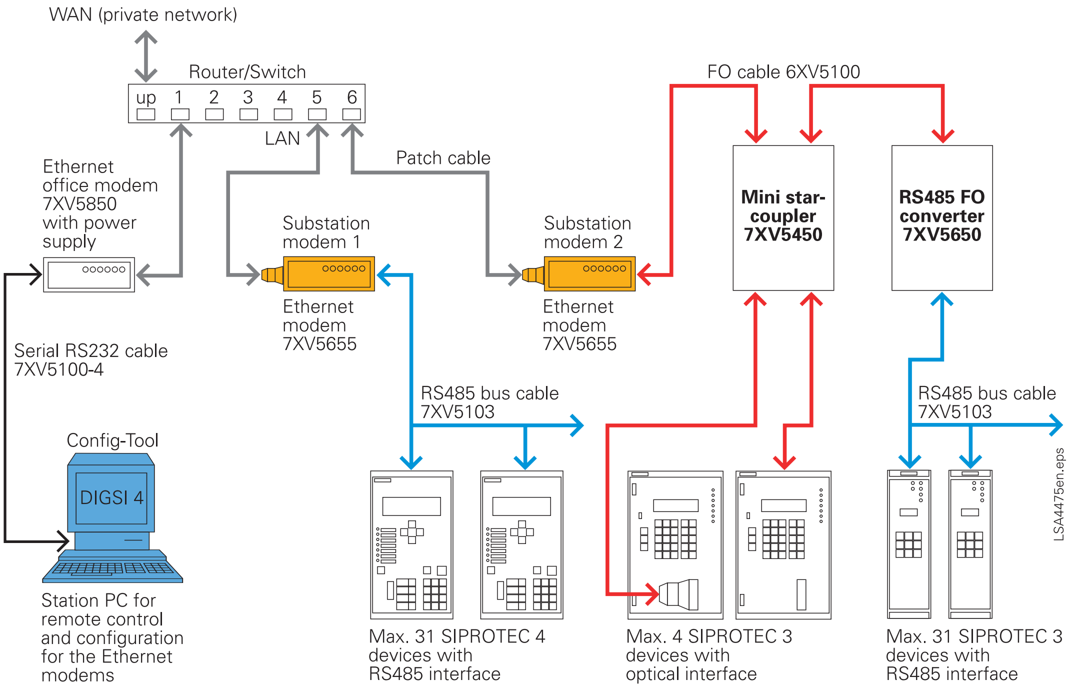


Fig. 14/48
Operation of various SIPROTEC protection unit generations via Ethernet modems

Using the office computer and DIGSI 4, both substations 1 and 2 may be dialed up via the Ethernet modems. An IP point-to-point data connection is established between the office and corresponding substation modem when dialed up via the network. This is maintained until the office modem terminates the connection. The serial data exchange takes place via this data connection whereby the modem converts the data from serial to Ethernet with full duplex mode. Between the office modem and the office PC the highest baud rate e.g. 57.6 kB /s for SIPROTEC 4 devices is always used. The serial baud rate of the substation modem is adapted to the baud rate required by the protection relays e.g. substation modem 1 with 57.6 kB/s for SIPROTEC 4 and substation modem 2 with 9.6 kB/s for SIPROTEC 3 devices. These settings are only pre-set once in the modem.

The Ethernet modems are integrated similarly to telephone modems in DIGSI 4. Instead of the telephone number, the pre-set IP address assigned to the modem is selected. If later an Ethernet connection is available in the substation, the existing modem can be replaced by an Ethernet modem. The entire serial bus structure and cabling may remain unchanged.

Technical data

Connections			
RS232 interface 9-pol. SUB-D or RS485 interface 9-pol. SUB-D settable by switches FO interface 820 nm with ST connectors for the connection to 62.5/125 µm multi-mode FO cables. Ethernet 10BaseT, 10/100 Mbit, RJ45 connector Power supply / Fail safe relay with screw-type terminals			
Housing			
Rail mounting, plastic, charcoal grey, 90 x 90 x 107 (W x H x D) in mm			
Wide-range power supply / fail safe relay			
Auxiliary voltage 24 to 250 V DC and 115/230 V AC connected with screw-type terminals Fail safe relay for power supervision connected with screw-type terminals			
Indication (8 x LED)			
Power	Operating voltage ok	System	RS232 connection established
RS232 T x D	Transmitting data to RS232	RS232 R x D	Receiving data from RS232
LAN T x	Transmitting data to LAN	LAN R x	Receiving data from LAN
Error	Error on RS232	Link LAN	LAN connection established

Selection and ordering data

Description	Order No.
Ethernet modem	*7XV5655 - 0BB00*

Ethernet modem for serial, asynchronous transmission of data up to
57.6 kbit/s via the 10/100 Mbit Ethernet and configuration software
DIN-rail device mounting device suitable for substation.
Connection to Ethernet via RJ45 connector. Serial connection SUB-D 9-pin socket
RS232/RS485 interface settable by switches.
FO interface 820 nm for 62.5/125 µm multi-mode - FO cables.
Auxiliary supply 24 - 250 V DC and 115/230 V AC.
Fail safe contact for device supervision.
With gender-changer (pin-pin) for adaptation to
DIGSI - cable 7XV5100-4 (cable not included in the scope of supply).

14

7XV5655-0BA00
Ethernet Serial Hub for Substations

Fig. 14/49
Front view of Ethernet serial hub for substation

Description

By means of the serial hub and the associated configuration software it is possible to establish serial communication via an Ethernet network between a PC or notebook running DIGSI 4 and SIPROTEC protection relays. The configuration software installs virtual serial interfaces (Com ports) on the PC. Each COM port is allocated to a serial hub within the network by means of its IP address. This must be set in the serial hub. The PC is connected to the network via Ethernet interface. The protection relays are connected via an RS232/RS485 or FO interface to the serial hub. The connection with DIGSI is effected via the virtual COM port on the PC and the IP address of the serial hub in the substation. The serial data is packed as user data into a secure IP protocol in the PC and transferred via the Ethernet connection to the serial hub. The requirements regarding standard compliant gap-free transmission of serial DIGSI or IEC 60870-5-103/101 telegrams (frames) via the network is complied with by the communication driver on the PC and the serial hub which monitor the serial telegram communication. The serial IEC telegrams are transferred in blocks across the Ethernet. The data communication is full duplex. The control signals of the serial interfaces are not used.

Function overview

- Configuration software for Windows NT/2000/XP to configure virtual COM ports on the PC and for configuration of the serial hub.
- RS232/RS485 - interfaces for data transfer and configuration of the serial hub
- FO interface for serial data transfer
- Serial baud rate and data format (RS232) for the terminal devices is selectable from 2400 Bd up to 57.6 kBd with data format 8N1, 8E1.
- 10 Mbit Ethernet interface (LAN) to the 10/100 Mbit Ethernet network.
- Better security with password protection for the access to the protection relays via the serial hup
- Exchange of serial data via Ethernet network (e.g. DIGSI protocol, IEC 60870-5-103 protocol)
- Exchange of serial protocols via Ethernet without gaps in the telegram structure

Application

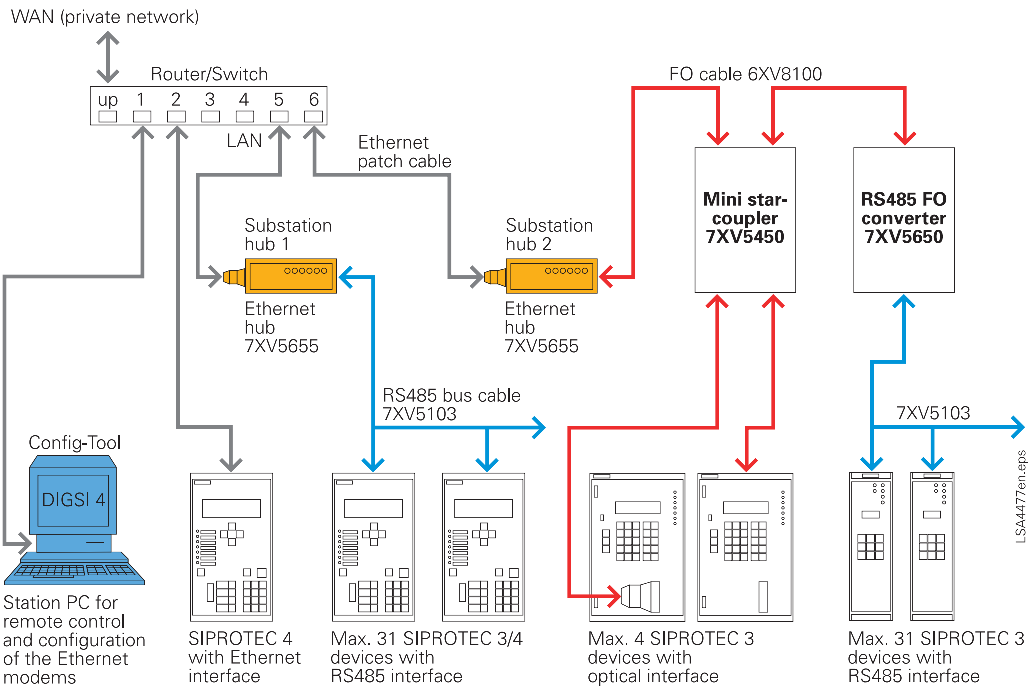


Fig. 14/50
Operation of various SIPROTEC protection unit generations via serial hub

From the office PC running DIGSI 4 it is possible to select one of the serial hubs 1 and 2 via one of the virtual COM ports. In DIGSI 4, when the COM port is selected, a IP point-to-point data connection via the network is established and maintained between the office and the relevant substation modem until the interface is released. The serial data exchange takes place via this data link, whereby the data conversion from serial to Ethernet is full duplex. The office PC towards the network is always operating with high baud rate, as the data is fed to the network via the network driver on the PC. The serial baud rate of the serial hub in the substation is adapted to the baud rate set in the protection relay, e.g. serial hub 1 with 57.6 kB/s for SIPROTEC 4 and serial hub 2 with 9.6 kB/s for SIPROTEC 3 devices. These parameters must be pre-set on the serial hub. With DIGSI 4 the serial hubs are integrated by means of further serial COM ports (max. 254). The connection to the IP address of the serial hub in the network is achieved by opening the corresponding COM port. If an Ethernet network to the substation or in the substation is available, serial data can then be transferred via this network.

The existing serial star or bus structure with cabling in the substation can still be used.

SIPROTEC 4 devices from version 4.6 and newer with integrated Ethernet interface may be connected directly to the router or switch by means of a patch cable.

Technical data

Connections			
RS232 interface 9-pin SUB-D socket or RS485 interface 9-pin SUB-D socket selectable via DIL switch. FO interface 820 nm with ST connectors for connection to multi-mode FO cables. Ethernet 10BaseT, 10/100 Mbit, RJ45 connector to Ethernet Auxiliary voltage/alarm relay (5 terminals)			
Housing			
Rail mounting, plastic, charcoal grey, 90 x 90 x 107 (W x H x D) in mm			
Wide-range power supply			
Auxiliary voltage 24 to 250 V DC and 115/230 V AC connected with screw-type terminals Alarm relay for monitoring of the device			
Indication (8 x LED)			
Power	Operating voltage ok	System	RS232 connection established
RS232 T x D	Transmitting data to RS232	RS232 R x D	Receiving data from RS232
LAN T x	Transmitting data to LAN	LAN R x	Receiving data from LAN
Error	Error on RS232	Link LAN	LAN connection established

Selection and ordering data

Description	Order No.
Ethernet hub for substations	*7XV5655 - 0BA00*

Serial hub for serial, asynchronous transfer of data up to 57.6 kbit/s via 10/100 Mbit Ethernet including configuration software.
Connection to the Ethernet via RJ45 connector. Serial connection with RS232/RS485 interface via SUB-D 9-pin socket or optical with 820 nm ST connector and multi-mode FO cable.
Wide-range auxiliary supply for 24 - 250 V DC and 115/230 V AC.
With gender-changer (pin-pin) for adaptation to
DIGSI cable 7XV5100-4 (cable not included in the scope of supply).

14

7XV5850/5851
Ethernet Modems for Office Applications

Fig. 14/51
7XV585x Ethernet modem

Function overview

- DIGSI supports the administration and the setting-up of connections via the Ethernet network.
- RS232 interfaces for data transfer and configuration of the modem.
- Serial baud rate and data format (RS232) for the terminal devices is selectable from 2400 Bd up to 57.6 kBd with data format 8N1, 8E1.
- An Ethernet interface LAN to the 10/100 Mbit network.
- Better security with password protection and IP address selection is possible.

Description

A control PC and protection units can exchange serial data via an Ethernet network using two Ethernet modems 7XV585x. Connection to the Ethernet modem is in each case made via the asynchronous serial interface of the terminal units. In the modem, the serial data is packed into the secure IP protocol as information data, and is transferred between the modems using the Ethernet connection. Conformity with the standard and gap-free transmission of serial DIGSI or IEC 60870-5-103/ 101 telegrams via the network is ensured by the modem which receives the serial telegram communication and packs the serial IEC telegrams into blocks for communication via the Ethernet. The data is transmitted in full duplex mode; serial control wires are not supported. The connection is established between the IP address of the dialing modem in the office and the IP address of the pick-up modem in the substation, and is configured prior to dialing up with DIGSI by means of AT commands via the RS232 interface.

The substation modem may be configured to have password protection, and provides the additional security feature, whereby access is only permitted from defined IP addresses, e.g. only that of the office modem. The modem is accessed with DIGSI Remote like a normal telephone modem with the exception that instead of telephone numbers, IP addresses are assigned by the network administrator for each modem.

Application

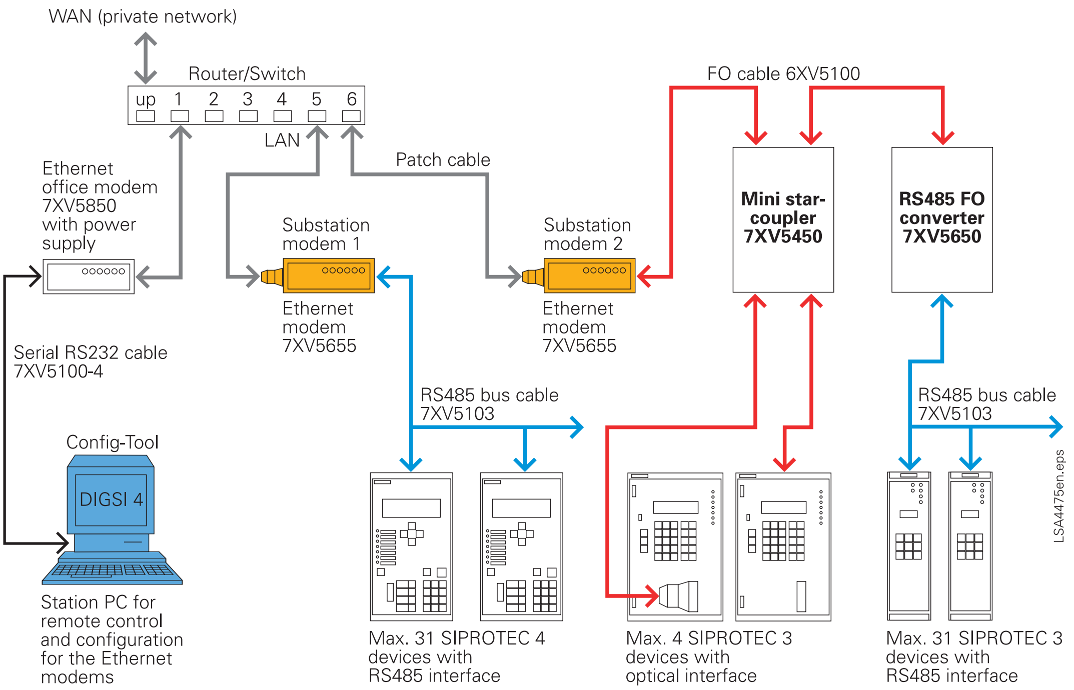


Fig. 14/52
Operation of various SIPROTEC protection unit generations via Ethernet modems

Using the office computer and DIGSI 4, both substation 1 and 2 may be dialed up via Ethernet modems. A TCP/IP point-to-point data connection is established between the office modem and corresponding substation modem when dialed up via the network. This is maintained until the office modem terminates the connection. The serial data exchange takes place via this data connection, with the modem converting the data from serial to Ethernet with full duplex mode. Between the office modem and the office PC, the highest baud rate is always used, e.g. 57.6 kB for SIPROTEC 4 units. The serial baud rate of the substation modem is adapted to the baud rate required by the protection relays, e.g. substation modem 1 with 57.6 kB for SIPROTEC 4 and substation modem 2 with 9.6 kB for SIPROTEC 3 units. These settings are only defined once in the modem. The Ethernet modems are integrated in DIGSI 4 similar to telephone modems. Instead of the telephone number, the pre-set IP address assigned to the modem is selected.

If later an Ethernet connection is available in the substation, the existing modem can be replaced by an Ethernet modem. The entire serial bus structure and cabling may remain unchanged.

Technical data

Connections	
RS232 interface 9-pin, SUB-D connector Ethernet 10BaseT, 10/100 Mbit, RJ45 Power supply (see below)	
Desktop device for office use 7XV5850-0AA00	
Housing	Desktop housing, plastic, charcoal grey, 46 x 109 x 74 (W x H x D) in mm
Supply	Wide-range plug-in power supply, auxiliary voltage 100 - 240 V AC
Scope of supply	With RS232 cable for Notebook/PC. With Ethernet cable (cross-over) 2 m
Modem for rail mounting 7XV5851-0AA00	
Housing	Rail mounting, plastic, charcoal grey, 46 x 109 x 74 (W x H x D) in mm
Supply	Auxiliary voltage 18 - 24 V DC (screw-type terminal), expandable with 7XV5810-0BA00
Scope of supply	With RS232 cable to SIPROTEC 4, 7XV5300, 7XV5550, 7XV5652. With Ethernet cable (cross-over) 2 m for configuration
Indication (8 x LED)	
Power	Operating voltage ok
RS232 TxD	Transmitting data to RS232
LAN Tx	Transmitting data to LAN
Error	Error on RS232
System	RS232 connection established
RS232 RxD	Receiving data from RS232
LAN Rx	Receiving data from LAN
Link LAN	LAN connection established

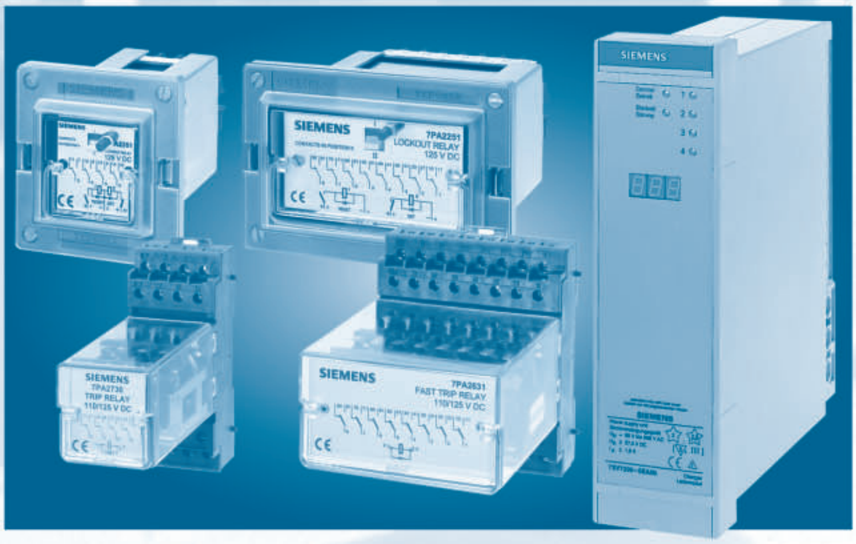
Selection and ordering data

Description	Order No.
Ethernet Modem	*7XV585☐ - 0AA00*
Ethernet modem for serial, asynchronous transmission of data up to 57.6 kbit via the 10/100 Mbit Ethernet and configuration software	
Desktop device (office version) Connection to Ethernet via RJ45 connector, serial connection SUB-D 9-pin socket including wide-range power supply 100/240 V AC With cross-over Ethernet patch cable 2 m for configuration With serial connection cable to PC 2 m	*0*
EN 50022 rail device (preferred as substation modem) Connection to Ethernet via RJ45 connector, serial connection SUB-D 9-pin socket Auxiliary supply 18 - 24 V DC (other voltages with 7XV5810-0BA00) including cross-over Ethernet patch cable 2 m and serial connection cable to SIPROTEC 4, 7XV5300, 7XV5450, 7XV5550, 7XV5652 2 m	*1*

14

Test Equipment and Accessories

Page



7XV75 Test Switch

Fig. 15/1 7XV75 test switch

Function overview

The following versions are available in a flush-mounting housing:

- For feeder protection without an open star point
- For feeder protection without an open star point and with additional contacts
- For feeder protection without an open star point for two CT cores or separate earth-fault CT
- For feeder protection with an open star point
- For feeder protection with an open star point and independently switchable trip and CT circuits
- For a 3-winding transformer differential protection

Description

The 7XV75 test switch serves for testing protection relays including CT circuits and command contacts. With the help of the switches located on the front side, the current and voltage inputs as well as the circuits of the protection relay to be tested are interrupted and applied to the front side. Via this plug-in connector, currents and voltages can be fed by an injection test set and the different commands and indications can be tested.

15

Technical data

Test switch	
Rated operating voltage V_n	400 V AC
Rated operating current I_n	6 A
Test current capacity	for 1 s 150 A for 10 s 60 A
Unit design	
Metal housing	7XP20
Dimension	1/6 of 19” wide
Weight	Approx. 3.4 kg

Selection and ordering data

Description	Order No.
7XV75 test switch	*7XV750□-□CA00*
Without open star point for feeder protection	*0*
With open star point for feeder protection	*1*
For 3-winding transformer differential protection	*2*
Without open star point for two CT cores or separate earth-fault CT	*3*
Without open star point for feeder protection and with additional contacts	*7*
With open star point and independently switchable trip and CT circuits for feeder protection	*8*
Front test plug connection	
With 16-pin Harting connector	*0*
With 16 banana connectors	*1*
Connecting cable 7XV6200 for 7XV75 test switch with 2 meter cable	
with 16-pin Harting connector and 17 isolated banana connectors 4 mm with cable marks	*7XV6201-5*
with 16-pin Harting connector and 17 cable end sleeves with cable marks	*7XV6201-6*

15

7PA22/23/26
Auxiliary Relays for Various Applications

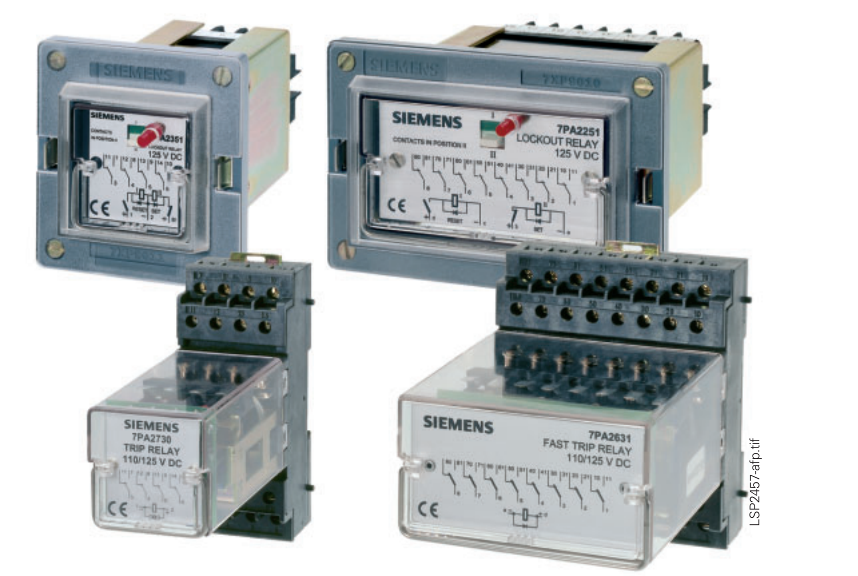


Fig. 15/2 7PA2 auxiliary relays

Description

Due to their quality, reliability and design, these relays are optimal for applications requiring high reliability and availability such as power stations, substations, railway and industrial plants. Typical examples include petrochemical industry, chemical industry, cement industry, rolling mills etc.

The relays comply with the IEC, EN, IEEE standards (type and routine test) and bear the CE mark.

The robust switch contacts are characterized by high make/break capacity, overload capability and continuous current intensity capacity; thus perfect insulation is obtained. Direct control of high-voltage and medium-voltage switchgear is possible.

Their high degree of protection and the transparent cover ensure reliable operation in tropical and/or salty sea air ambient conditions.

Technical data

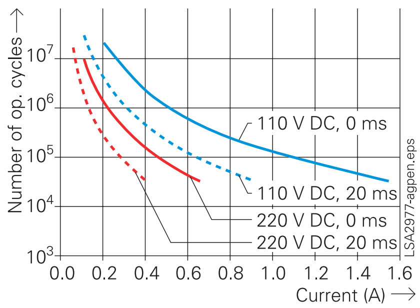
Switching contacts	
Continuous current	10 A
Overload capability	80 A/200 ms 150 A/10 ms
Switching current/voltage	40 A/0.5 s/110 V DC

Breaking capacity for 10^5 operating cycles

	Non-inductive		Inductive, 20 ms	
	1 contact	2 contacts in series	1 contact	2 contacts in series
V DC	A	A	A	A
24	6.6	12.7	3.2	6.0
60	2.6	4.9	1.4	2.7
125	1.2	2.2	0.6	1.1
220	0.6	1.1	0.3	0.6

For details see characteristics

V_{max}, open contact	250 V DC/400 V AC
Mechanical service life	10^7 operating cycles
Operating temperature	- 10 °C to + 55 °C 14 °F to 131 °F
Max. permissible humidity	93 % at 40 °C/104 °F
Seismic stress class according to IEEE 501	
Degree of ZPA	3 *g* acceleration at 33 Hz



Standards

Electrical tests performed according to IEC 60255	
- Dielectric test	2 kV/50 Hz/ 1 min
- Surge withstand test	5 kV/1.2/50 µs
- Insulation	> 2000 MΩ/ 500 $V_{peak-to-peak}$
Flammability tests according to IEC 60692-2-1	
Plastic materials	UL 94: VO, IEC 60695: 850 °C/30 s 1562 °F/30 s
Degree of protection acc. to IEC 60529	Relay: IP 40 With socket cover: IP 50
Climatic stress test according to	
- IEC 60255-7 dry heat	Non-dissipating unit +70 °C/96 h 158 °F/96 h Dissipating unit +55 °C/96 h 131 °F/96 h
- IEC 60068-2-30 cyclic humid heat	+55 °C/12 h 131 °F/12 h
- IEC 60068-2-1 cold	100 cycles Non-dissipating unit -10 °C/2 h 14 °F/2 h
- IEC 60255-7 thermal aging test	At rated voltage V_N +55 °C/1440 h 131 °F/1440 h

15

7PA22
Fast-acting lockout relay

Description

The bistable 7PA22 is a fast-acting lockout relay with eight changeover contacts and is plugged into a mounting frame equipped with a plug-in socket (type 7XP9010) with screw-type terminals at the rear.

Functions

No continuous power consumption. Position indication on the front side. Mechanical reset pushbutton.
Position memory with two positions (e.g. for yes/no, open/close, auto/manual, local/remote etc.).

Technical data

While the auxiliary voltage is being supplied to the SET coil, the reset pushbutton must not remain pushed longer than 20 s.

Rated voltages and consumption

V_N	Voltage range	Consumption while switching
V DC	V DC	
24	19 - 26	
30	24 - 33	
60	48 - 66	≤ 48 W
110	88 - 121	
125	100 - 137	
220	176 - 242	

Pick-up time: < 10 ms

General description see page 15/5.
Refer to part 16 for dimension drawings.

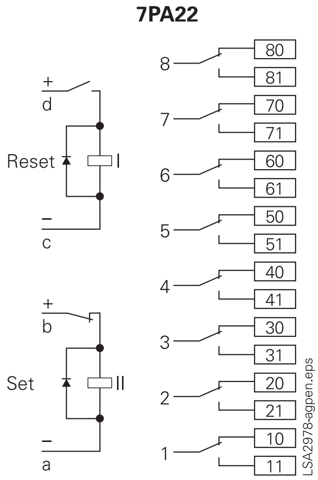


Fig. 15/3 Connection diagram

Selection and ordering data

Description	Order No.
7PA22 fast-acting lockout relay	*7PA22□1-□*
Auxiliary voltage	
24 V DC	1
60 V DC	2
110 V DC	3
220 V DC	4
125 V DC	5
30 V DC	6
Socket	
without socket	0
with flush-mounting socket 7XP9010-1	1

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	7XP9010-1
Surface mounting	7XP9012-0

Protection functions

7PA23
Fast-acting lockout relay

Description

The bistable 7PA23 is a fast-acting lockout relay with four changeover contacts and is plugged into a mounting frame equipped with a plug-in socket (type 7XP9011) with screw-type terminals at the rear.

Functions

No continuous power consumption. Position indication on the front side. Mechanical reset pushbutton.
Position memory with two positions (e.g. for yes/no, open/close, auto/manual, local/remote etc.).

Technical data

While the auxiliary voltage is being supplied to the SET coil, the reset pushbutton must not remain pushed longer than 20 s.

Rated voltages and consumption

V_N	Voltage range	Consumption while switching
V DC	V DC	
24	19 - 26	≤ 24 W
30	24 - 33	
60	48 - 66	
110	88 - 121	
125	100 - 137	
220	176 - 242	

Pick-up time: < 8 ms
General description see page 15/5.
Refer to part 16 for dimension drawings.

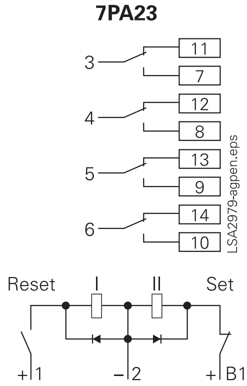


Fig. 15/4 Connection diagram
Contacts represented in position RESET

Selection and ordering data

Description	Order No.
7PA23 fast-acting lockout relay	*7PA23□1-□*
Auxiliary voltage	
24 V DC	*1*
60 V DC	*2*
110 V DC	*3*
220 V DC	*4*
125 V DC	*5*
30 V DC	*6*
Socket	
without socket	*0*
with flush-mounting socket 7XP9011-1	*1*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9011-1*
Surface mounting	*7XP9013-0*

7PA26 Monostable relay

Description

The monostable 7PA26 has eight change-over contacts and is plugged into a mounting frame equipped with a plug-in socket (type 7XP9010) with screw-type terminals at the rear.

Technical data

Rated voltages and consumption

V_N V DC	Voltage range V DC	Consumption
24/30	19 - 33	7PA26☐1: ≤ 6 W Peak: ≤ 45 W 7PA26☐0: ≤ 5 W
60	48 - 66	
110/125	88 - 137	
220	176 - 242	

Pick-up time:	7PA26☐0 < 20 ms 7PA26☐1 < 10 ms
Drop-out time:	< 40 ms

General description see page 15/5.
Refer to part 16 for dimension drawings.

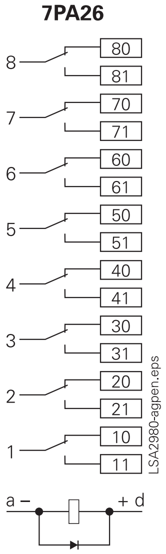


Fig. 15/5 Connection diagram

Selection and ordering data

Description	Order No.
7PA26 monostable relay	*7PA26☐☐-☐*
Auxiliary voltage	
24 /30 V DC	*1*
60 V DC	*2*
110/125 V DC	*3*
220 V DC	*4*
Standard, 20 ms	*0*
Fast, 10 ms1)	*1*
Socket	
without socket	*0*
with flush-mounting socket 7XP9010-0	*1*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9010-0*
Surface mounting	*7XP9012-0*

1) Note: The maximum energization period for the fast version 7PA26☐1 is 200 hours. For permanent energization the normal version 7PA26☐0 should be applied.

7PA27/30
Auxiliary Relays for Various Applications

NEW

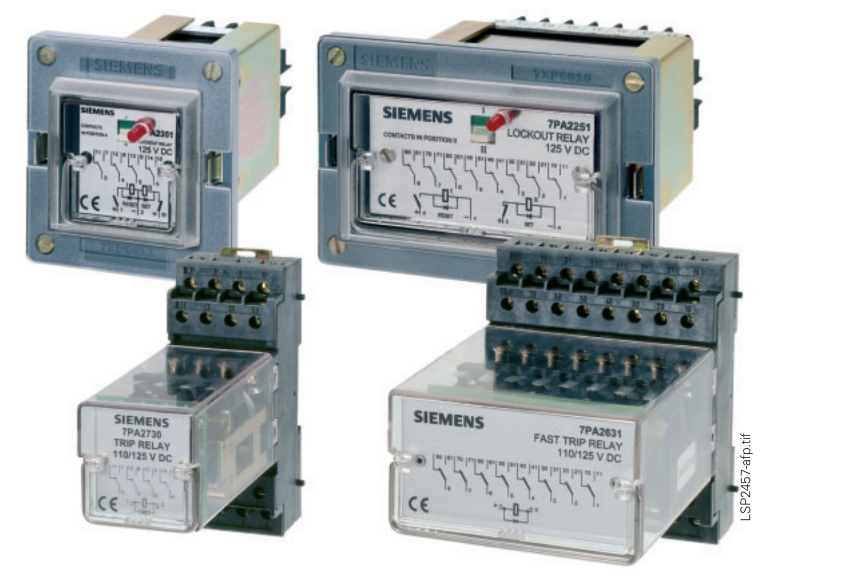


Fig. 15/6 7PA2 auxiliary relays

Description

Due to their quality, reliability and design, these relays are optimal for applications requiring high reliability and availability such as power stations, substations, railway and industrial plants. Typical examples include petrochemical industry, chemical industry, cement industry, rolling mills etc.

The relays comply with the IEC, EN, IEEE standards (type and routine test) and bear the CE mark.

The robust switch contacts are characterized by high make/break capacity, overload capability and continuous current intensity capacity; thus perfect insulation is obtained. Direct control of high-voltage and medium-voltage switchgear is possible.

Technical data for 7PA27

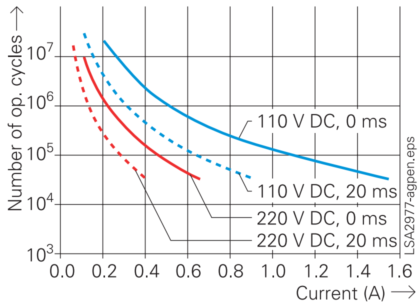
Switching contacts	
Continuous current	10 A
Overload capability	80 A/200 ms 150 A/10 ms
Switching current/voltage	40 A/0.5 s/110 V DC

Breaking capacity for 10^5 operating cycles

	Non-inductive		Inductive, 20 ms	
	1 contact	2 contacts in series	1 contact	2 contacts in series
V DC	A	A	A	A
24	6.6	12.7	3.2	6.0
60	2.6	4.9	1.4	2.7
125	1.2	2.2	0.6	1.1
220	0.6	1.1	0.3	0.6

For details see characteristics

V_{max}, open contact	250 V DC/400 V AC
Mechanical service life	10^7 operating cycles
Operating temperature	- 10 °C to + 55 °C 14 °F to 131 °F
Max. permissible humidity	93 % at 40 °C/104 °F



Technical data for 7PA30

Contacts	
Permanent current	8 A
Instantaneous current	15 A
Making capacity	40 A/0.5 s/110 V DC
Breaking capacity	0.3 A/110 V DC
U_{max} opened contact	250 V DC/400 V AC
Mechanical life	10^7 operations
Operating temperature	-10 °C +55 °C
Storage temperature	-30 °C +70 °C
Operating humidity	93 %/40 °C

Standards

Electrical test performed acc. to IEC 60255-5

Dielectric test	2 kV / 50 Hz / 1 min
Surge withstand test	5 kV / 1.2 / 50 µs
Insulation	>2000 MΩ / 500 Vcc
Inflammability tests Plastic materials	UL94: VO
Degree of protection acc. to IEC 60529	Relay: IP40

Climatic stress test acc. to IEC 60068-2

Dry cold, operation	- 10 °C
Dry heat, operation	+ 55 °C
Storage and transport	- 25 °C + 70 °C

Constructions standards (Cont'd)

Immunity test EMC

EN 60255-22-1	High frequency 1 MHz burst disturbance test: Test level: 1 MHz, 400 imp/s, 2 s Common mode: 2,5 kV Differential mode: 1 kV
EN 61000-4-4	Electrical Fast transient burst: Test level 4 kV, 2.5 kHz, 1 min · 2 kV, 5 kHz, 1 min
EN 61000-4-5	Surge 8/20 µs (current) 1.2/50 µs (voltage) Common mode: 2 kV-Differential mode: 1 kV
EN 61000-4-3	Radiated electromagnetic field: Test level: 80-1000 MHz, 10 V/m, 80 % AM (1 kHz)
EN 61000-4-3	Digital telephones radiated electromagnetic field: Test level: 900 ± 5 MHz, 10 V/m, 50 % (200 Hz) 1.89 GHz ± 10 MHz, 10 V/m, 50 % (200 Hz)
EN 61000-4-6	Conducted disturbances induced by radio frequency fields. Test level: 0.15-80 MHz, 10 V, 80 % AM (1kHz)
EN 61000-4-2	Electrostatic discharges: Test level: Contact ± 15 kV; Air mode ± 15 kV
EN 61000-4-8	Power frequency magnetic field: Test level: 100 A/m 1 min · 1000 A/m 1 s
EN 55011 Class A	Emission test: Test level: Cover: 30-230 MHz, 40 dB(µV/m) (quasi peak)-10 m 230-1000 MHz, 47 dB(µV/m) (quasi peak)-10 m Power supply: 0.15-0.5 MHz, 79 dB(µV) (quasi peak)/ 66 dB average 0.5-5 MHz, 73 dB(µV) (quasi peak)/ 60 dB average 5-30 MHz, 73 dB(µV) (quasi peak)/ 60 dB average

7PA27 Monostable fast-acting relay

Description

The monostable 7PA27 is a fast-acting relay with four changeover contacts.

Technical data

Rated voltages and consumption

V_N	Voltage range	Consumption Normal	Peak
V DC	V DC	mA	
24/30	19 - 36	28	1 A/20 ms
60	42 - 72	12	1 A/20 ms
110/125	77 - 150	8	0,3 A/20 ms
220	154 - 264	6	0,3 A/20 ms

- Pick-up time: < 8 ms
- Drop-out time: < 40 ms

General description see page 15/5.
Refer to part 16 for dimension drawings.

7PA27

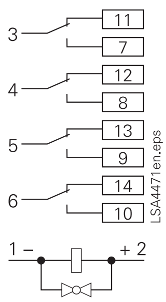


Fig. 15/7 Connection diagram

Selection and ordering data

Description	Order No.
7PA27 monostable fast-acting relay	*7PA27□2-0AA00-□*
Auxiliary voltage	
24 / 30 V DC	*1*
60 V DC	*2*
110 / 125 V DC	*3*
220 V DC	*4*
Socket	
without socket	*0*
with flush-mounting socket 7XP9011-2	*1*
with surface-mounting socket 7XP9013-0	*2*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9011-2*
Surface mounting	*7XP9013-0*

NEW

7PA30 Three-phase Trip circuit supervision

Description

The relay is for supervision of the trip circuit of a circuit breaker with three selective trip coils. The trip circuit wiring is supervised from the positive supply to the negative supply whilst the circuit breaker is open or closed.

Functions

The design, quality and rugged construction of the relay make it suitable for applications requiring high levels of reliability/dependability. The high degree of protection guarantees reliable operation over a wide temperature range, even under extreme environmental conditions.

The relay has been tested in accordance with IEC, EN and IEEE standards. The relay is CE marked. The supervision current is always less than 1,4 mA thus avoiding unwanted operation of the trip coil. Correct operation is shown via a green LED.

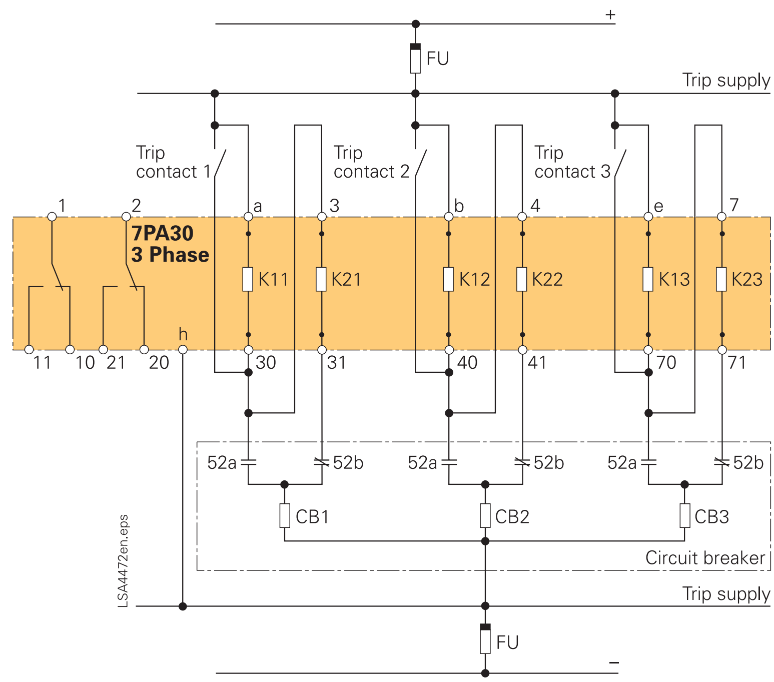


Fig. 15/8 Connection diagram for 3-phase relay

Standard voltages and consumption

V_N	Voltage range	Consumption	Impedance per phase	Pickup Drop out Voltage	
V DC	V DC	mA	kΩ/s	V DC	
24/30	18 - 33	35	20	between	12 and 18
60	42 - 66	20	44		36 and 42
110/125	77 - 138	20	94		66 and 77
220	154 - 242	15	200		132 and 154

Drop-out time: between 200 ms and 400 ms

Selection and ordering data

Description	Order No.
7PA30 trip circuit supervision (three-phase)	*7PA30☐2-3AA00-☐*
Auxiliary voltage	
24/30 V DC	*1*
60 V DC	*2*
110/125 V DC	*3*
220 V DC	*4*
Socket	
without socket	*0*
with flush-mounting socket 7XP9010-4	*1*
with surface-mounting socket 7XP9012-0	*2*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9010-4*
Surface mounting	*7XP9012-0*

NEW

7PA30 Single-phase Trip circuit supervision

Description

The relay is for supervision of the trip circuit of a circuit breaker with one trip coil. The trip circuit wiring is supervised from the positive supply to the negative supply whilst the circuit breaker is open or closed.

Functions

The design, quality and rugged construction of the relay make it suitable for applications requiring high levels of reliability/dependability. The high degree of protection guarantees reliable operation over a wide temperature range, even under extreme environmental conditions.

The relay has been tested in accordance with IEC, EN and IEEE standards. The relay is CE marked. The supervision current is always less than 1,4 mA thus avoiding unwanted operation of the trip coil. Correct operation is shown via a green LED.

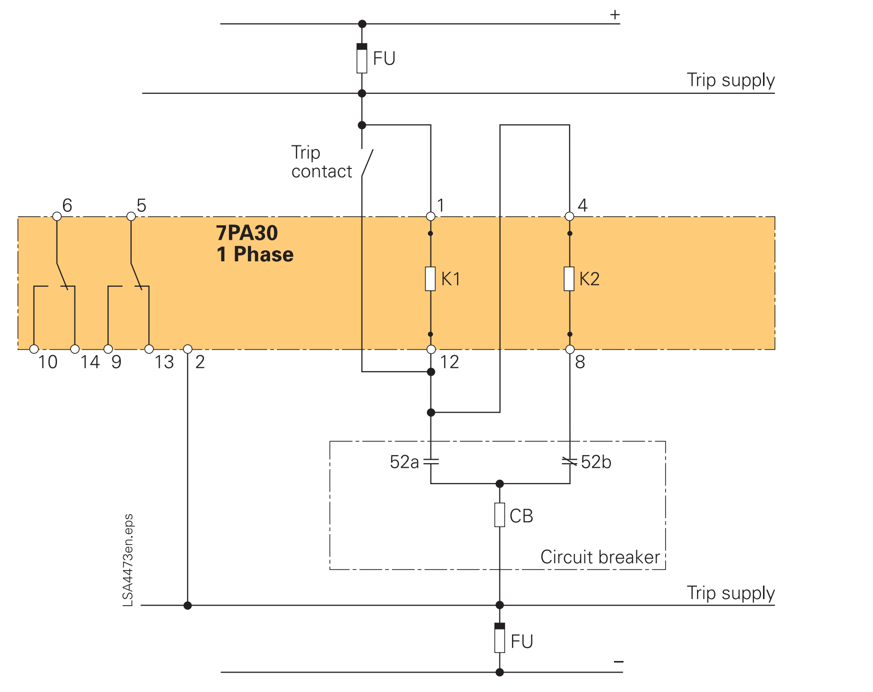


Fig. 15/9 Connection diagram for 1-phase relay

Standard voltages and consumption

V_N	Voltage range	Consumption	Impedance per phase	Pickup Drop out Voltage	
V DC	V DC	mA	kΩ/s	V DC	
14/30	18 - 33	32	20	between	12 and 18
60	42 - 66	18	44		36 and 42
110/125	77 - 138	18	94		66 and 77
220	154 - 242	13	200		132 and 154

Drop-out time: between 200 ms and 400 ms

Selection and ordering data

Description	Order No.
7PA30 trip circuit supervision (single-phase)	*7PA30□2-1AA00-□*
Auxiliary voltage	
24/30 V DC	*1*
60 V DC	*2*
110/125 V DC	*3*
220 V DC	*4*
Socket	
without socket	*0*
with flush-mounting socket 7XP9011-0	*1*
with surface-mounting socket 7XP9013-0	*2*

Accessories

Description	Order No.
Socket as spare part	
Flush mounting	*7XP9011-0*
Surface mounting	*7XP9013-0*

7TS16 Annunciation Relay

Fig. 15/10 7TS16 annunciation relay

Description

The 7TS16 relay features auxiliary trip indication for local and remote signaling. It has four independent output contacts and LED indication. The relay complies with the IEC and EN standards and bears the CE mark.
The 7TS16 is a reliable and versatile high-speed relay with four signal inputs. It has four local LEDs and auto-resetting output contacts, used in SCADA controls. Additionally, it features two diode tripping circuits.
Reset is possible via remote input and via local reset push button.
The reset should not be permanently switched on.

Function overview

- Indications: Four LEDs, latching type, signaling until reset.
- Inputs: Four alarm/trip inputs
  - Input for remote reset
  - Push button for local reset
- Outputs: For each alarm/trip input:
  - One diode 2.5 A
  - One potential free changeover contact
  - One potential free NO contact
  - One common tripping output through diode (2.5 A; V_{max} 220 V DC)
- Contacts:
  - Permanent current 8 A
  - Instantaneous current 15 A
  - Making capacity 15 A /4 s /110 V DC
  - Breaking capacity 0.3 A /110 V DC

Technical data

- Rated voltages (V_N):
  24/30, 110/125, 220 V DC
- Voltage range V_N +10 % - 20 %
- Operating temperature -10 to +55 °C
- Operating humidity 93 %/40 °C
- Pickup time < 5 ms
- Consumption

For one trip

V_N	
24/30 V DC	1 A/3 ms
110/125 V DC	3 A/2 ms
220 V DC	4 A/3 ms

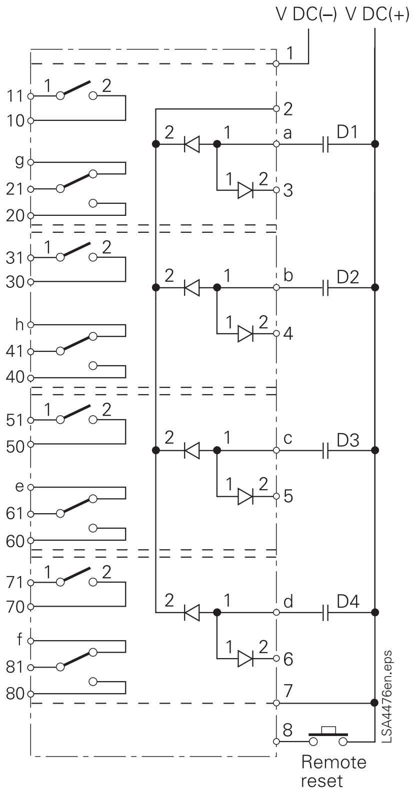
For a permanent trip

V_N	mA
24/30 V DC	21
110/125 V DC	8
220 V DC	6.5

For a latched LED

V_N	mA
24/30 V DC	1
110/125 V DC	3
220 V DC	5

Connection diagram



2	Direct common trip output
3, 4, 5, 6	Direct trip output
1(-), 7(+)	Auxiliary supply

Fig. 15/11 Connection diagram
Contacts represented without auxiliary supply in the relay

Standards

Electrical tests performed acc. to IEC 60255	
- Dielectric test	2 kV/50 Hz/ 1 min
- Surge withstand test	5 kV/1.2/50 µs
High-frequency test acc. to IEC 60255-22-1	
- Common mode	2.5 kV / 1 MHz
- Differential mode	1 kV / 1 MHz
Inflammability tests Plastic materials	UL94: VO
Degree of protection acc. to IEC 60529	Relay: IP40
Climatic stress test acc. to IEC 60068-2	
Dry cold, operation	- 10 °C
Dry heat, operation	+ 55 °C
Storage and transport	- 30 °C + 70 °C

Selection and ordering data

Description	Order No.
7TS16 annunciation relay with 4 LEDs	*7TS16☐2-0AA00-☐*
Rated auxiliary voltage	
24/30 V DC	*1*
110/125 V DC	*3*
220 V DC	*4*
Socket	
Without socket	*0*
With flush-mounting socket 7XP9010-2	*1*
With surface-mounting socket 7XP9012-0	*2*
Socket as spare part	
Flush mounting	*7XP9010-2*
Surface mounting	*7XP9012-0*

15

7SV73 Power Supply Unit

Fig. 15/12
Charging module

Fig. 15/13
Battery box

Description

The 7SV73 power supply unit is used for stations without a central DC voltage supply, i.e. stations too small to merit the use of a station battery. During normal operation, the power unit supplies the numerical protection relays with energy from the power supply unit while keeping the batteries fully charged. This energy is drawn either from the 100 V voltage transformer secondary circuit or from the 230 V station AC voltage.

In the event of a fault, the power unit 7SV73 is able to maintain an uninterruptible supply to the protection relays and at the same time operate circuit-breaker coils, if necessary. This energy is provided by two series-connected batteries, i.e. all components must have a voltage input of $V_N = 24$ V.

Function overview

The 7SV73 power supply unit features the following functions:

- Automatic battery connection in the event of a power failure (uninterruptible)
- For battery fault detection, the battery medium-voltage is fed to the monitor via fuse F4
- Exhaustive discharge protection with battery disconnection on drop below limit voltage
- Optical display with 6 LEDs on the front panel on the charging module
- One alarm relay with the group indication: battery operation and relay disturbance
- Three-position LED seven-segment display

Because of the large battery capacity, several protection relays can be powered and several circuit-breakers operated at the same time. The output power given in the technical data must be taken into account.

Selection and ordering data

Description	Order No.
7SV73 power supply unit in 7XP20 housing	7SV7320-0☐A00
Unit design (charging module)	
For panel surface mounting, terminal connection on side	B
For panel flush mounting, cubicle mounting	E
Battery set	
For replacement, two spare batteries (Panasonic, LC R 12 V 6.5 PD)	7XV2200-2AA00

3RV16 Voltage Transformer Circuit-Breaker

Fig. 15/14
3RV16 voltage transformer circuit-breaker

Function overview

Application

- Protection of voltage-transformer secondary circuits for the connection of protection relays with voltage-dependent starting element

Functions

- Auxiliary contact of 3RV16 prevents the distance protection tripping via the underimpedance starting in case of a fault in the voltage transformer circuits
- Tripping time of instantaneous element in few milliseconds

Construction

- Snap-on mounting on 35-mm mounting rail, or screw mounting

Description

The voltage transformer circuit-breaker protects the secondary side of voltage transformers used to connect protection relays with voltage-dependent starting. The switch is used for distance protection with low-impedance starting. Special auxiliary contacts reliably prevent low-impedance starting from triggering distance protection if only one error has occurred in the converter line.

The voltage transformer circuit-breaker can also be used to safely disconnect the distance protection relay from the voltage transformer. In this case the special auxiliary contacts also prevent erratic triggering of the distance protection.

Additional fuses are not required. A “Fuse Failure Monitor” (FFM) is also not required.

The circuit-breakers are snap-mounted on a 35-mm mounting rail to EN 50022. Push-in lugs are available for screw-type connection of the circuit-breakers.

The circuit-breaker for voltage transformers also incorporates 2 auxiliary contacts (normally 1 NO + 1 NC). During the closing operation, contact making via the NO contact of the control switch takes place later than via the main contacts, whereas during the opening operation the auxiliary circuits are interrupted at the same time as the main circuits, if not before. This adjustment has the effect of preventing the opening of the circuit-breaker from producing a tripping command via the underimpedance starting of the distance protection relay.

The auxiliary voltage for blocking voltage-dependent starting (underimpedance) must always be routed via the NO contact 11-14.

Functions

The voltage transformer circuit-breaker largely corresponds with the circuit-breaker 3RV1, SIRIUS, size S00. Two special characteristics are taken into account for safe prevention of faulty triggering of the distance protection relay.

Auxiliary switch for blocking the distance protection

The main contacts of the circuit-breaker open if the voltage transformer circuit-breaker is tripped or switched off. The distance protection would falsely interpret low impedance as a fault, which results in immediate power cut-out within only a few milliseconds.

To prevent this fault response, special auxiliary contacts with a time-dependent assignment to the circuit-breaker's main contacts (see Technical data) must be provided. The distance protection is blocked with the help of these auxiliary contacts, and thus prevents faulty triggering.

An auxiliary switch for blocking the distance protection relay is available, equipped with 1 changeover contact fitted permanently in the voltage transformer circuit-breaker. This changeover contact can be used as 1 NO (11-14) or 1 NC (11-12) contact. Due to the high contact stability of these auxiliary contacts at the lowest possible rated operational currents I_e/AC-15 ≥ 0.5 mA at 230 V, it is also suitable for modern solid-state distance protection relays.

The laterally mountable auxiliary switches of the SIRIUS range can be used for signaling functions. They cannot be used for blocking the distance protection relay.

Impedance across the main contacts

There is only minor current flow across the main contacts of the voltage transformer circuit-breaker. To ensure reliable functioning of the distance protection, main contact resistance must be minimal and nearly constant throughout the service life of the circuit-breaker.

This is realized with suitable contacts and contact materials for the 3RV16 voltage transformer circuit-breaker.

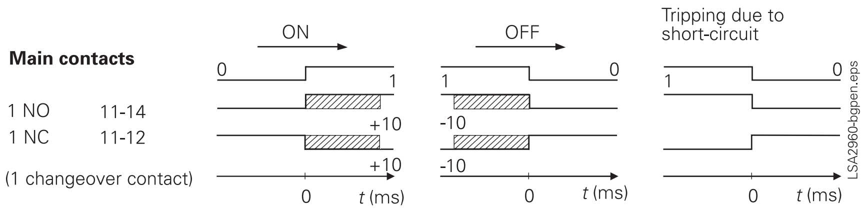
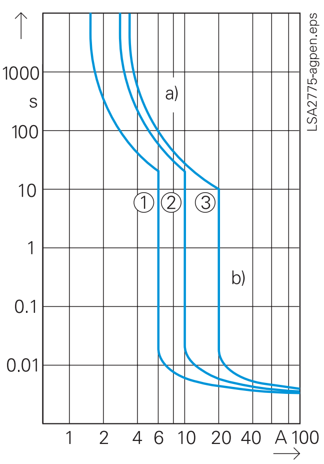


Fig. 15/15 Timing diagram of auxiliary switches for blocking distance protection

Characteristics

The specified tripping characteristics of the thermal overload pickup (a) correspond to the mean value of the leakage bandwidth in cold state; at operating temperature these times are reduced to approx. 25 % of the specified values. The characteristics below are schematic representations. Precise characteristics are available from "Technical Assistance" (E-mail: nst.technical-assistance@siemens.de).



① 1.4 A/6 A
② 2.5 A/10.5 A
③ 3 A/20 A
a) Thermal overload pickup
b) Instantaneous electromagnetic surge trip

Fig. 15/16 Characteristics

Connection diagrams

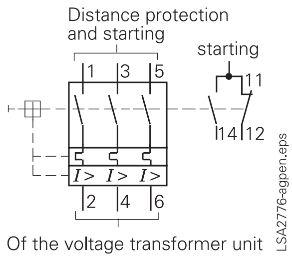
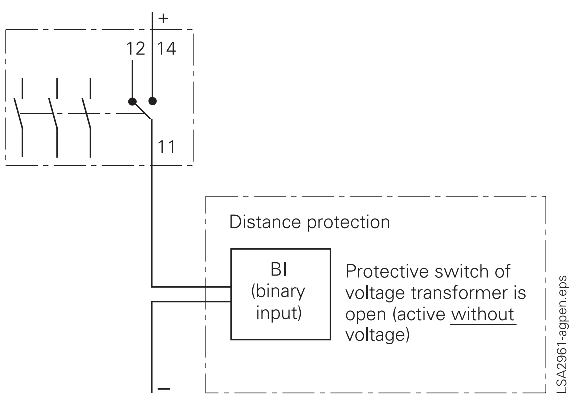


Fig. 15/17 Internal connections



Note:
When using the NC contact to connect the voltage transformer circuit-breaker, the binary input of the distance protection device (Siemens 7SA xxx) should be set to "active without voltage". This type of connection is used for additional monitoring of correct wiring.

Fig. 15/18 Typical connections

Technical data

Conductor cross-sections, main circuit, 1 or 2 conductors			
Type	3RV1611- 1AG14	1CG14	1DG14
Terminal type	Screw connection		
Terminal screw	Prozidriv size 2		
Solid	2 x (0.5 to 1.5 mm^2); 2 x (0.75 to 2.5 mm^2); (max. 4 mm^2);		
Finely stranded with end sleeve	2 x (0.5 to 1.5 mm^2); 2 x (0.75 to 2.5 mm^2)		
Stranded	2 x (0.5 to 1.5 mm^2); 2 x (0.75 to 2.5 mm^2); (max. 4 mm^2)		
Auxiliary switch for blocking the distance protection			
With defined time-dependent assignment for blocking distance protection	1 changeover contact, solid-state compatible (usable as 1 NO or 1 NC)		
Rated operational current I_E/ rated operational voltage V_E	AC-14 0.5 A/V_E 250 V AC-14 1 A/V_E 125 V DC-13 0.27A/V_E 250 V DC-13 0.44 A/V_E 125 V		
Short-circuit protection for auxiliary circuit			
Fusible link, gL/gG	max. 10 A		
Miniature circuit-breaker, C characteristic	max. 6 A		

General technical data			
Type	3RV1611- 1AG14	1CG14	1DG14
Rated current	1.4	2.5	3
Permissible ambient temperature During storage/transport During operation	 -50 to +80 °C -20 to +60 °C (up to 70 °C possible with current reduction)		
Rated operational voltage V_E	400 V		
Rated frequency	16.7 to 60 Hz		
Rated insulation voltage V_I	690 V		
Short-circuit breaking capacity at 400 V AC, short-circuit proof up to	50 kA		
Current setting of the thermal overload release	1.4 A	2.5 A	3 A
Operating value of the instantaneous electromagnetic overcurrent release	6 ± 20 %	10.5 ± 20 %	20 ± 20 %
Tripping time of the instantaneous electromagnetic overcurrent release	Approx. 6 ms at 12 A	6 ms at 20 A	6 ms at 40 A
Disconnection life:			
short-circuit current I_p	Max. short-circuit disconnections		
≤ 0.1 kA 0.1 to 2 kA 2 kA to 50 kA	≤ 10 ≤ 3 1		
Internal resistance in cold state in heated state	 > 0.25 Ω ± 6.5 % > 0.30 Ω ± 6.5 %		
Shock resistance acc. to IEC 60068, Part 2-27	15 *g*		
Degree of protection acc. to IEC 60529	IP 20		
Touch protection acc.to DIN VDE 0106 Part 100	Safe against finger touch		
Service life mechanical electrical	Operating cycles 10000 10000		
Permissible mounting position	any		

Selection and ordering data

Description	Order No.
3RV16 voltage transformer circuit-breaker	
with 1 auxiliary contact, 1 changeover	
1.4/ 6 A	*3RV1611-1AG14*
2.5/10.5 A	*3RV1611-1CG14*
3/20 A	*3RV1611-1DG14*
Laterally mountable auxiliary switches 1 NO/NC	*3RV1901-1A*

15

Dimension drawings in mm / inch

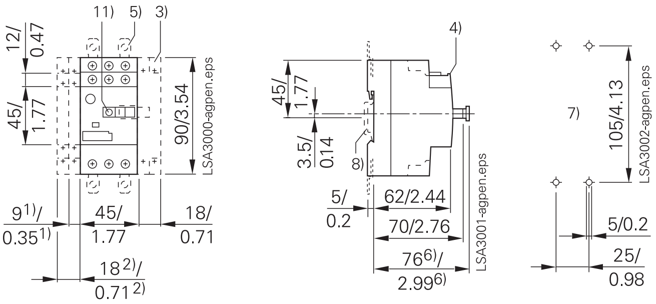
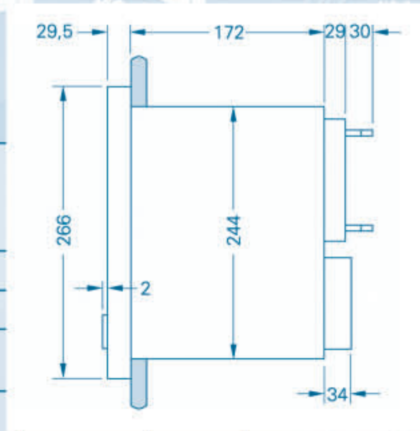


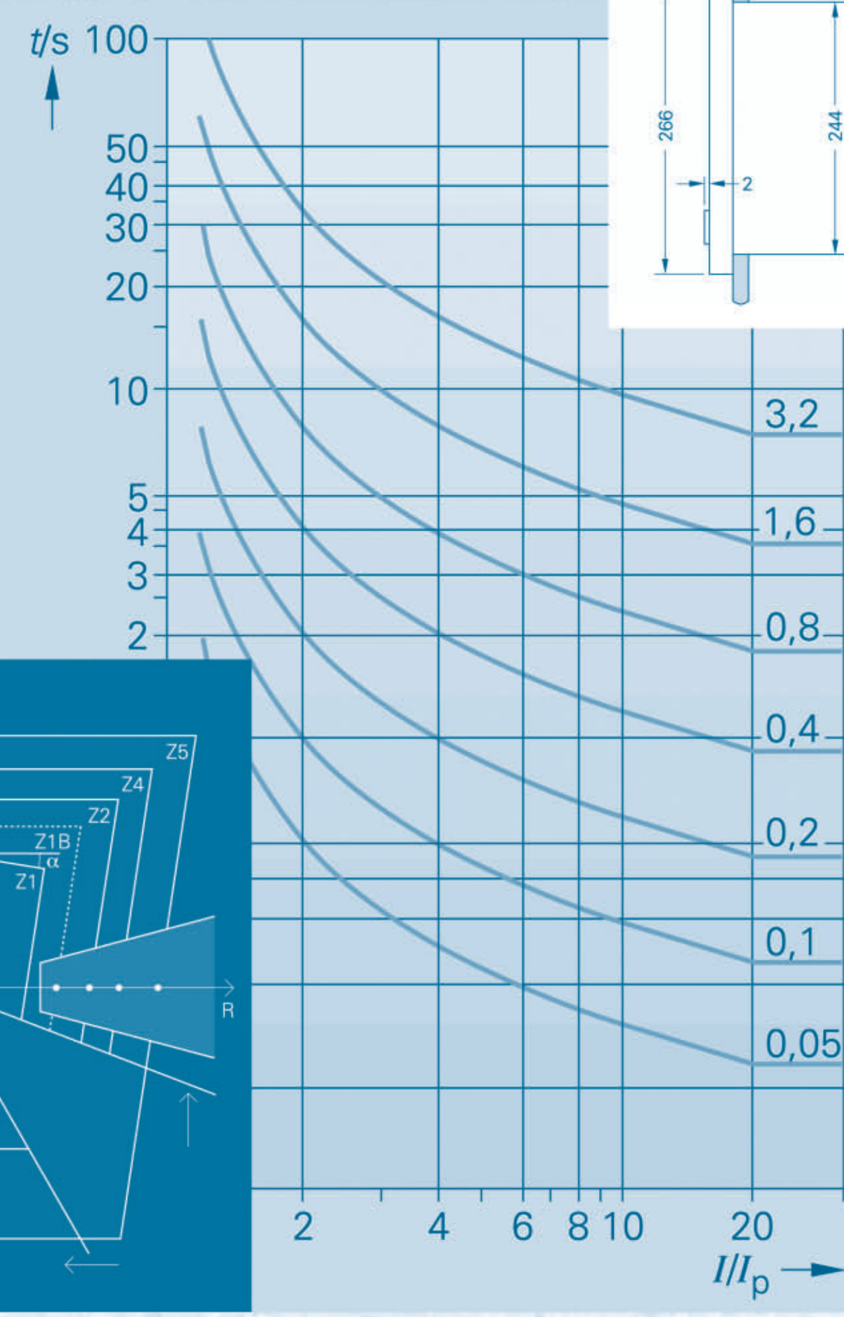
Fig. 15/19
7RV16 circuit-breaker

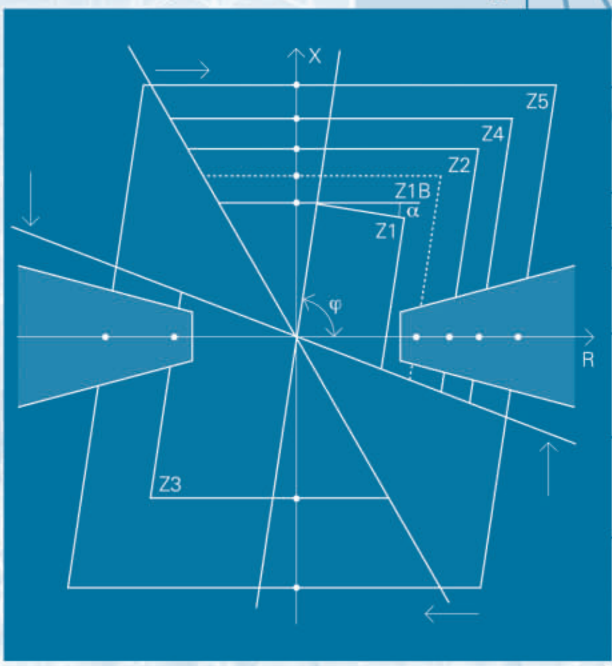
1) Auxiliary switch, 2-pole, located on the side.
2) Auxiliary switch, 4-pole, located on the side.
3) Auxiliary release.
4) Auxiliary switch transverse position.
5) Link for screw fixing.
6) Only with undervoltage release combined with leading auxiliary switch.
7) Drilling diagram.
8) Monitoring rail 35 mm, acc. to EN 50022.
11 Lockable in OFF position with padlock, bracket diameter 3.5 to 4.5 mm

Appendix

Page







Relay characteristics

Inverse-time characteristics of TOC relays

	IEC 60255-3				ANSI/IEEE						
	Normal inverse	Very inverse	Extremely inverse	Long inverse	Inverse	Short inverse	Long inverse	Definite inverse	Moderately inverse	Very inverse	Extremely inverse
Fig.	16/1	16/2	16/3	16/4	16/5	16/6	16/7	16/8	16/9	16/11	16/13
Relay											
7SD5	■	■	■	■	■	■	■	■	■	■	■
7SD610	■	■	■	■	■	■	■	■	■	■	■
7SJ450*-***00-0	■	■	■								
7SJ450*-***00-1									■	■	■
7SJ460*-***00-0	■	■	■								
7SJ460*-***00-1									■	■	■
7SJ600	■	■	■	■	■	■	■	■	■	■	■
7SJ602	■	■	■	■	■	■	■	■	■	■	■
7SJ61	■	■	■	■	■	■	■	■	■	■	■
7SJ62	■	■	■	■	■	■	■	■	■	■	■
7SJ63	■	■	■	■	■	■	■	■	■	■	■
7SJ64	■	■	■	■	■	■	■	■	■	■	■
7UM61	■	■	■		■			■	■	■	■
7UM62	■	■	■		■			■	■	■	■
7UT612	■	■	■	■	■	■	■	■	■	■	■
7UT613	■	■	■	■	■	■	■	■	■	■	■
7UT63	■	■	■	■	■	■	■	■	■	■	■

16

Relay characteristics

Inverse-time overcurrent protection characteristics according to IEC 60255 and BS142.

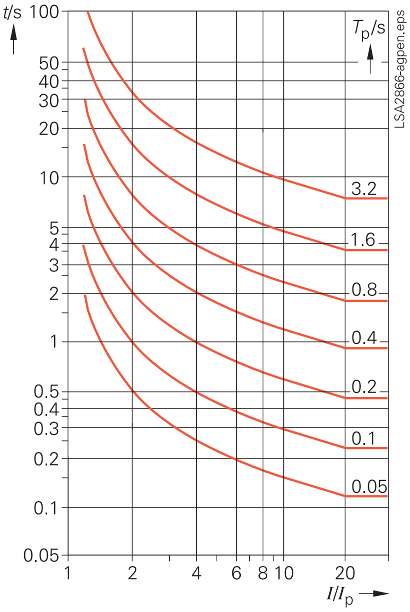


Fig. 16/1

Inverse

$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p$$

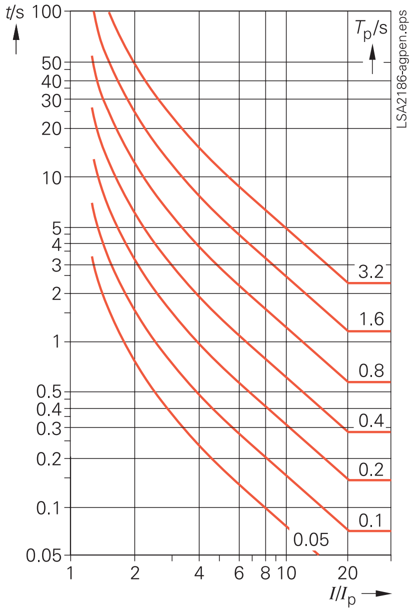


Fig. 16/2

Very inverse

$$t = \frac{13.5}{(I/I_p) - 1} \cdot T_p$$

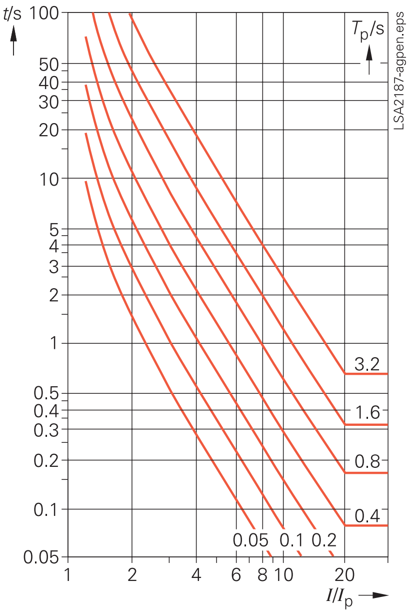


Fig. 16/3

Extremely inverse

$$t = \frac{80}{(I/I_p)^2 - 1} \cdot T_p$$

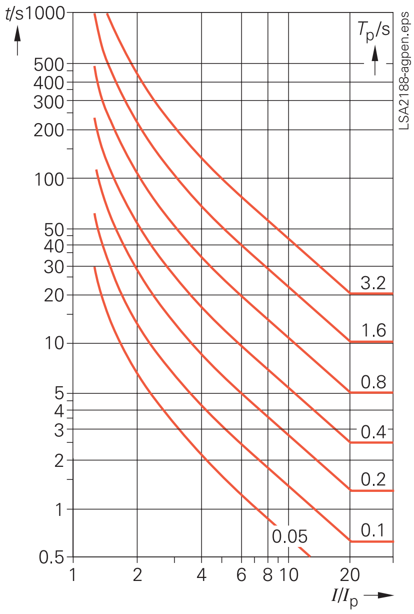


Fig. 16/4

Long inverse

$$t = \frac{120}{(I/I_p) - 1} \cdot T_p$$

I = current

t = tripping time

I_p = pickup setting

T_p = time multiplier setting

Relay characteristics

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

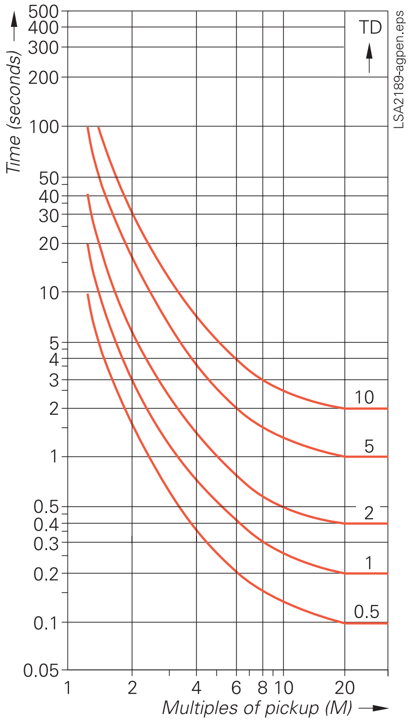


Fig. 16/5
Inverse

$$t = \left(\frac{8.9341}{M^{2.0938} - 1} + 0.17966 \right) \cdot TD$$

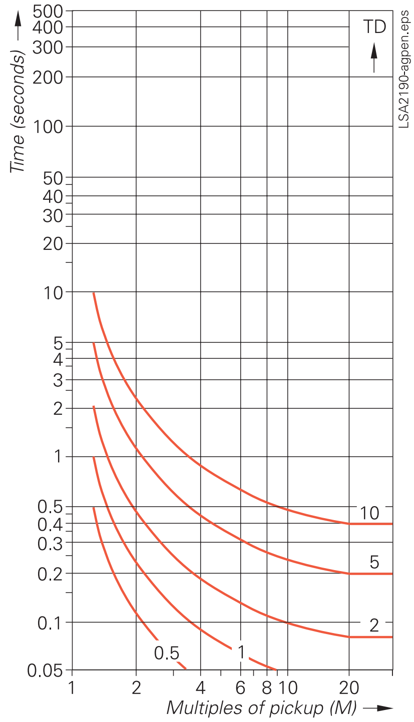


Fig. 16/6
Short inverse

$$t = \left(\frac{0.2663}{M^{1.2969} - 1} + 0.03393 \right) \cdot TD$$

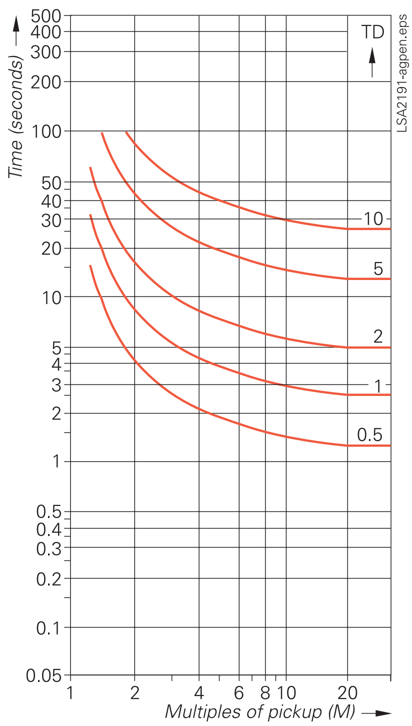


Fig. 16/7
Long inverse

$$t = \left(\frac{5.6143}{M - 1} + 2.18592 \right) \cdot TD$$

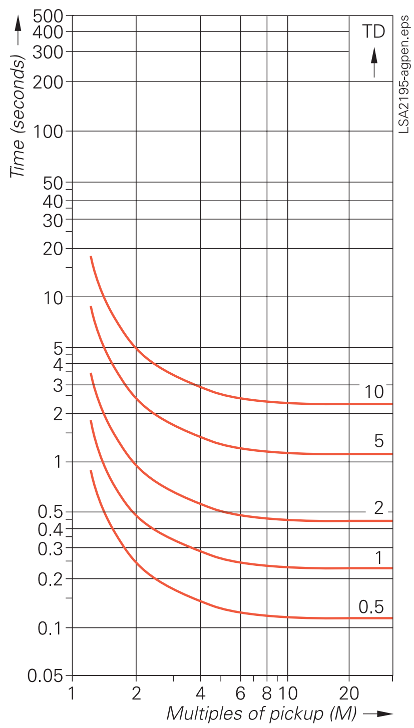


Fig. 16/8
Definite inverse

$$t = \left(\frac{0.4797}{M^{1.5625} - 1} + 0.21359 \right) \cdot TD$$

t = tripping time in seconds

M = current in multiples of pickup setting (I/Ip) range 0.1 to 4

TD = time dial

Relay characteristics

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

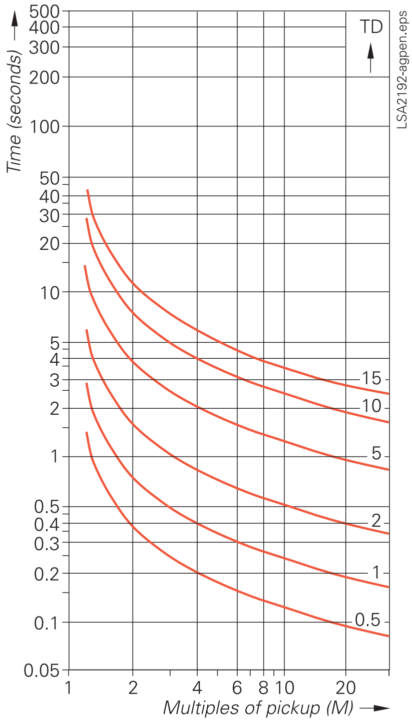


Fig. 16/9
Moderately inverse

$$t = \left(\frac{0.0103}{M^{0.02} - 1} + 0.0228 \right) \cdot TD$$

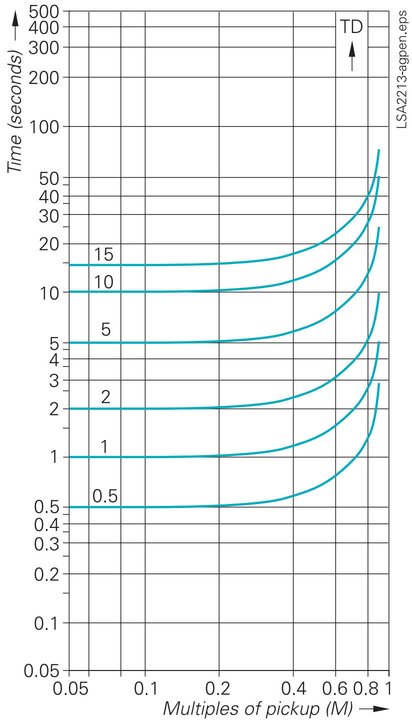


Fig. 16/10
Reset
moderately inverse

$$t_{\text{reset}} = \frac{0.97 \cdot TD}{M^2 - 1}$$

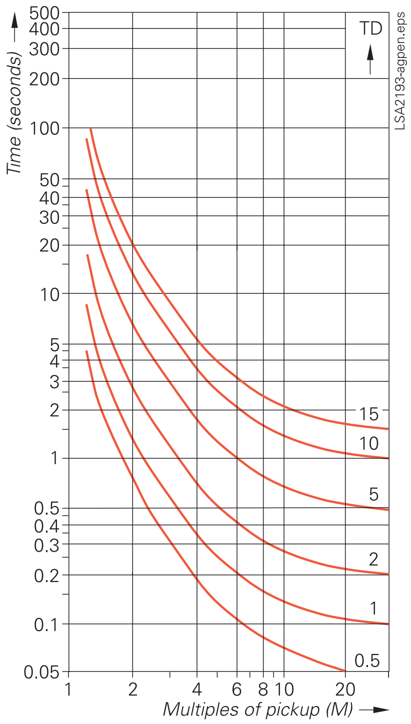


Fig. 16/11
Very inverse

$$t = \left(\frac{3.922}{M^2 - 1} + 0.0982 \right) \cdot TD$$

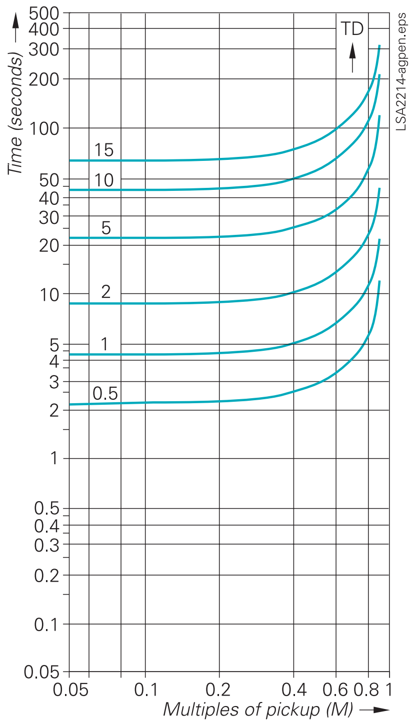


Fig. 16/12
Reset
very inverse

$$t_{\text{reset}} = \frac{4.32 \cdot TD}{M^2 - 1}$$

t = tripping time in seconds

M = current in multiples of pickup setting (I/Ip) range 0.1 to 4

TD = time dial

Relay characteristics

Inverse-time overcurrent protection characteristics according to ANSI (IEEE) C37.112

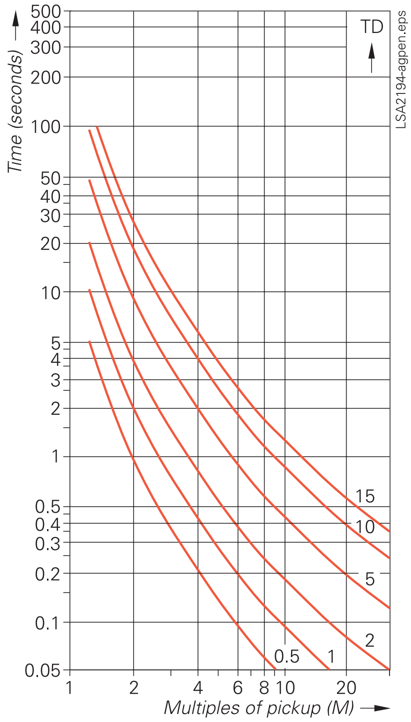


Fig. 16/13
Extremely inverse

$$t = \left(\frac{5.64}{M^2 - 1} + 0.0243\right) \cdot TD$$

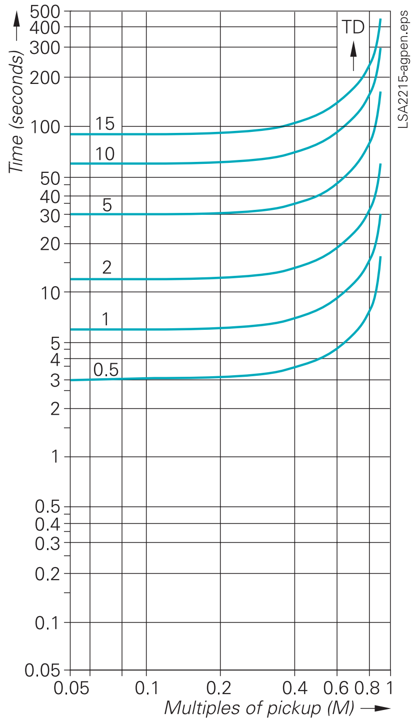


Fig. 16/14
Reset
extremely inverse

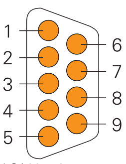
$$t_{reset} = \frac{5.82 \cdot TD}{M^2 - 1}$$

t = tripping time in seconds

M = current in multiples of pickup setting (I/Ip) range 0.1 to 4

TD = time dial

Pinout of communication port

		Port A: Time synchro-nisation	Port B: System interface				Port C/D Rear service interface or protection data interface	
Pin no.  LSA2375-bgp.eps	**PC interface at front**		RS232 IEC 60870-5-103	RS485 IEC 60870-5-103	RS485 PROFIBUS-FMS Slave, PROFIBUS-DP Slave	RS485 MODBUS, DNP 3.0	RS232	RS485
1	–	P24 input 24 V	Shield (with shield ends electrically connected)					
2	R x D	P5 input 5 V	R x D	–	–	–	R x D	–
3	T x D	common return	T x D	A/A' (RxD/TxD-N)	B/B' (RxD/TxD-P)	A	T x D	A
4	–	–	–	–	CNTR-A (TTL)	RTS (TTL level)	–	–
5	GND	Shield	GND	C/C' (GND)	C/C' (GND)	GND1	GND	C (GND)
6	–	–	–	–	+ 5 V voltage supply (max. Load < 100 mA)	VCC1	–	–
7	$\overline{RTS}$	P12 input 12 V	$\overline{RTS}$	–*)	–*)	–	$\overline{RTS}$	($\overline{RTS}$ RS232 used)
8	$\overline{CTS}$	–	$\overline{CTS}$	B/B' (RxD/TxD-P)	A/A' (RxD/TxD-N)	B	$\overline{CTS}$	B
9	–	Shield	–	–	–	–	–	–

*) Pin 7 also can carry the RS232 $\overline{RTS}$ signal to an RS485 interface. Pin 7 must therefore not be connected

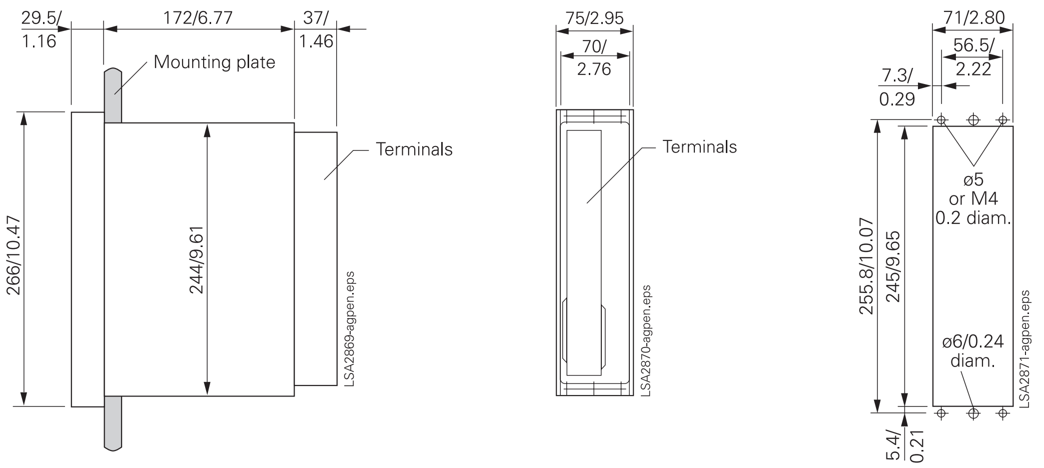
Dimension drawings

Reference table

Relay	Flush/cubicle-mounting version		Surface-mounting version		Detached HMI	
	Page	Fig.	Page	Fig.	Page	Fig.
6MD61	16/16	16/28	-	-	-	-
6MD63	16/12	16/24	16/15	16/27	16/16	16/28
6MD66	16/14	16/26	16/15	16/27	16/16	16/28
7KE6000	-	-	16/21	16/38, 16/39	-	-
7KG6000	-	-	16/23	16/48	-	-
7KG7000	-	-	16/22, 16/23	16/40 to 16/46	-	-
7KG775	-	-	16/22	16/41, 16/43	-	-
7KG8000	-	-	16/23	16/47	-	-
7PA22	16/24, 16/25	16/51, 16/53, 16/59	16/24, 16/25	16/51, 16/53, 16/59	-	-
7PA23	16/24, 16/25	16/52, 16/54, 16/60	16/24, 16/25	16/52, 16/54, 16/60	-	-
7PA26	16/24, 16/25	16/51, 16/53, 16/59	16/24, 16/25	16/51, 16/53, 16/59	-	-
7PA27	16/24, 16/25	16/52, 16/55, 16/58	16/24, 16/25	16/52, 16/55, 16/58	-	-
7PA30	16/24, 16/25	16/52, 16/57, 16/59, 16/60	16/24, 16/25	16/52, 16/57, 16/59, 16/60	-	-
3RV16	16/24	16/49	16/24	16/49	-	-
7RW600	16/8	16/15	16/8, 16/9	16/16, 16/17	-	-
7SA522	16/12, 16/14	16/24, 16/26	16/15	16/27	-	-
7SA61	16/11, 16/12, 16/13, 16/14	16/22, 16/24, 16/25, 16/26	16/11, 16/15	16/23, 16/27	-	-
7SA63	16/11, 16/12, 16/14	16/22, 16/24, 16/26	16/11, 16/15	16/23, 16/27	-	-
7SA64	-	-		-	16/16	16/28
7SD5	16/12, 16/14	16/24, 16/26	16/15	16/27	-	-
7SD600	16/8	16/15	16/8, 16/9	16/16, 16/17	-	-
7SD610	16/11	16/22	16/11	16/23	-	-
7SJ45	16/10	16/20	16/10	16/21	-	-
7SJ46	16/10	16/20	16/10	16/21	-	-
7SJ600	16/8	16/15	16/8, 16/9	16/16, 16/17	-	-
7SJ602	16/9	16/18	16/10	16/19	-	-
7SJ61	16/11	16/22	16/11	16/23	-	-
7SJ62	16/11	16/22	16/11	16/23	-	-
7SJ63	16/12, 16/14	16/24, 16/26	16/15	16/27	16/16	16/28
7SJ64	16/11, 16/12, 16/14	16/22, 16/24, 16/26	16/11, 16/15	16/23, 16/27	16/16	16/28
7SN600	16/8	16/15	16/8, 16/9	16/16, 16/17	-	-
7SS522 central unit	16/18	16/31	16/18	16/32	-	-
7SS523 bay unit	16/17	16/29	16/17	16/30	-	-
7SS525	16/11	16/22		-	-	-
7SS60	16/8, 16/20	16/15, 16/37		-	-	-
7SV600	16/8	16/15	16/8, 16/9	16/16, 16/17	-	-
7SV73	16/8	16/15	16/9	16/17	-	-
7TS16	16/24	16/53	16/25	16/59	-	-
7UM61	16/11, 16/12	16/22, 16/24	16/11, 16/15	16/23, 16/27	-	-
7UM62	16/11, 16/12	16/24, 16/26	16/15	16/27	-	-
7UT6	16/11, 16/12, 16/14	16/22, 16/24, 16/26	16/11, 16/15	16/23, 16/27	-	-
7VE61	16/11	16/22	16/11	16/23	-	-
7VE63	16/12	16/24	16/15	16/27	-	-
7VH60	16/8	16/15	16/9	16/17	-	-
7VK61	16/12	16/24	16/15	16/27	-	-
7XV5300	16/19	16/34	-	-	-	-
7XV5450	16/19	16/33	16/19	16/33	-	-
7XV5461	-	-	16/19	16/35	-	-
7XV5550	16/19	16/33	16/19	16/33	-	-
7XV5650/51/52/53/55	16/19, 16/23	16/33, 16/50	16/19, 16/23	16/33, 16/50	-	-
7XV5662	16/19, 16/23	16/35, 16/50	16/19, 16/23	16/35, 16/50	-	-
7XV75	16/20	16/36	-	-	-	-

Dimension drawings in mm / inch

Dimension drawings for 1/6 x 19" housing (7XP20)

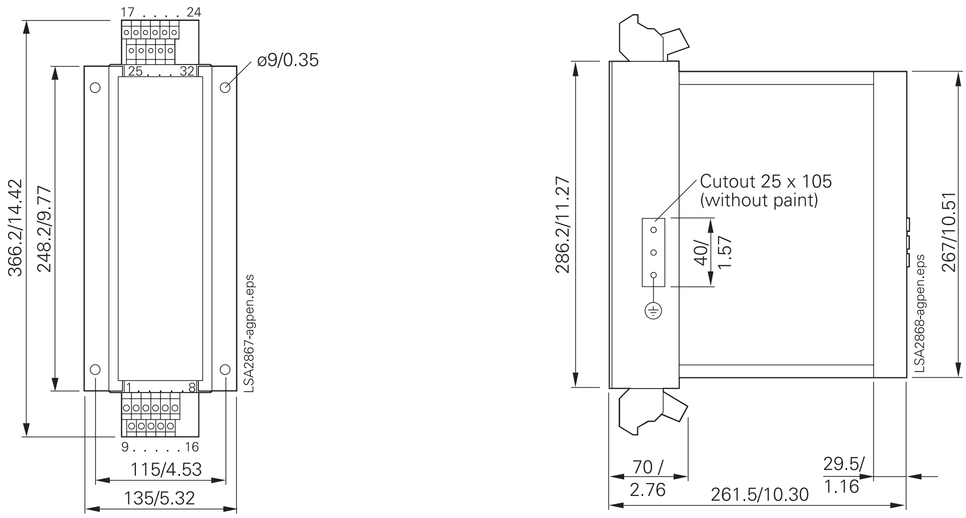


Side view

View from the rear

Panel cutout

Fig. 16/15
Housing for panel flush mounting/
cubicle mounting, terminals at rear (1/6 x 19")



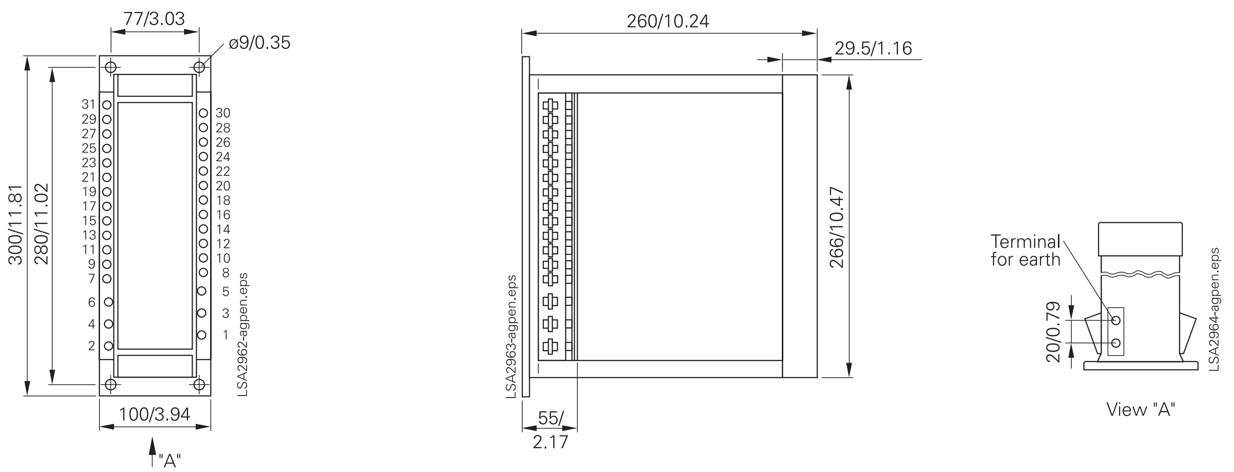
Front view

Side view

Fig. 16/16
Housing for surface mounting,
terminals at top and bottom (1/6 x 19")

Dimension drawings in mm / inch

Dimension drawings for 1/6 x 19" housing (7XP20)

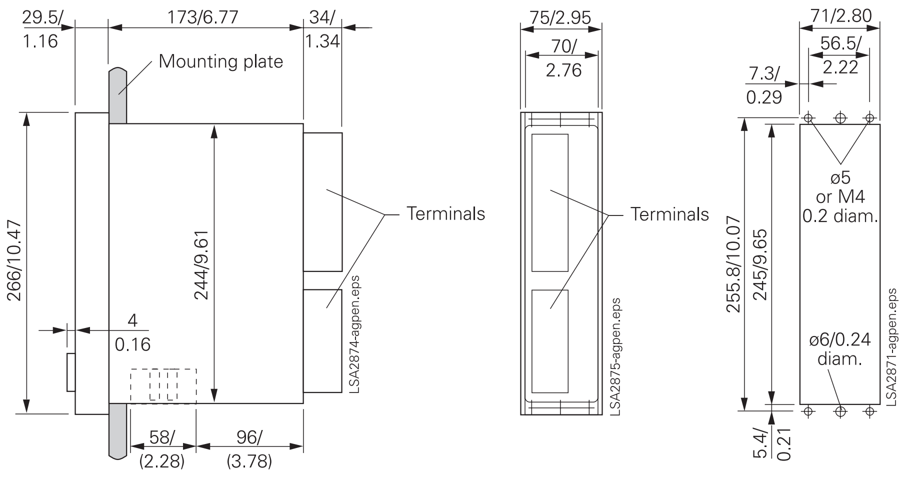


Front view

Side view

Fig. 16/17
Housing for panel surface mounting, terminals on the side (1/6 x 19")

Dimension drawings for SIPROTEC 7SJ602



Side view / screw-type terminals

View from the rear

Panel cutout

Fig. 16/18
7SJ602 with7XP20 housing
for panel flush mounting/cubicle mounting,
terminals at rear

Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 7SJ602

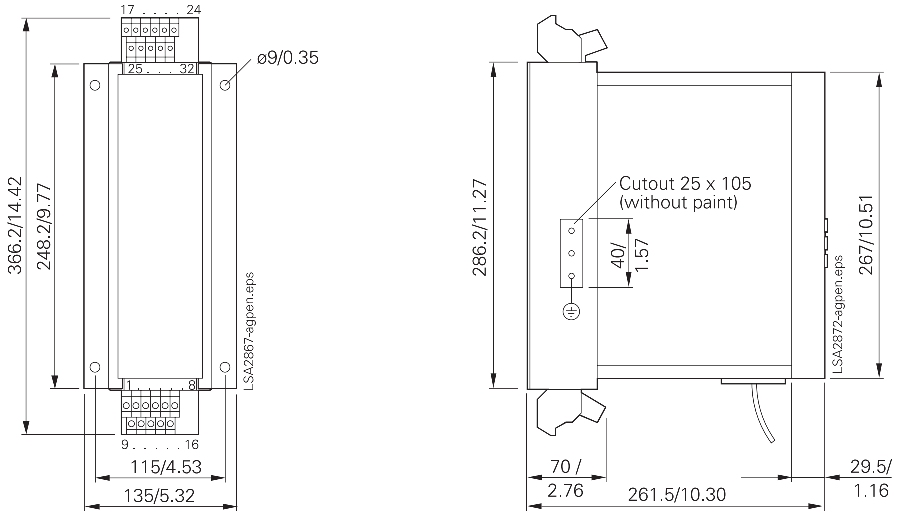
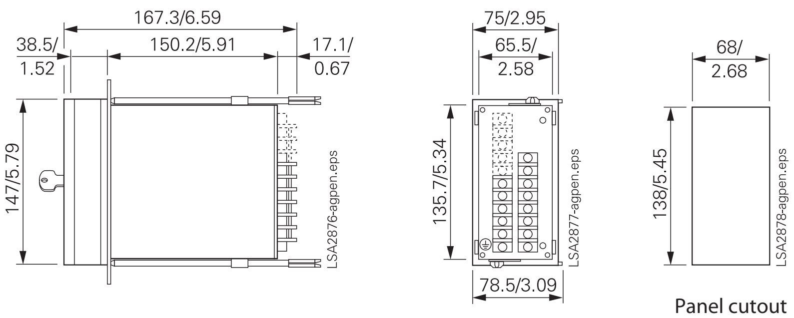


Fig. 16/19
7SJ602 with 7XP20 housing for surface mounting, terminals at top and bottom

Dimension drawings for SIPROTEC easy



Panel cutout

Fig. 16/20
7SJ45, 7SJ46 housing for panel flush mounting

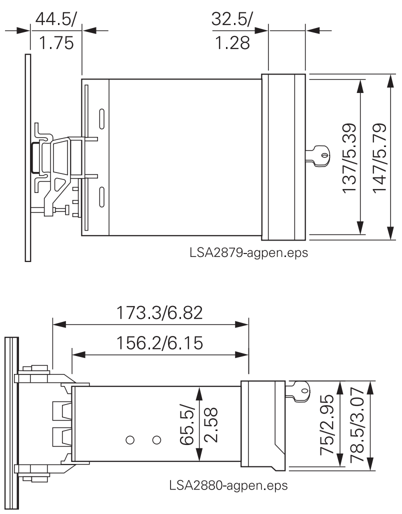
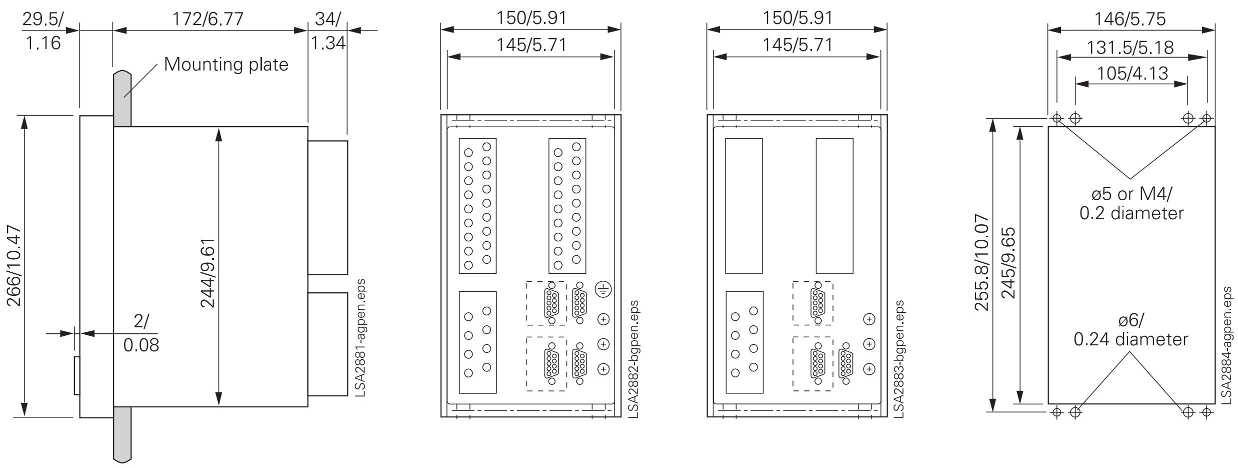


Fig. 16/21
7SJ45, 7SJ46 housing for rail mounting

16

Dimension drawings in mm / inch

Dimension drawings for SIPROTEC 4
1/3 x 19" housing (7XP20)



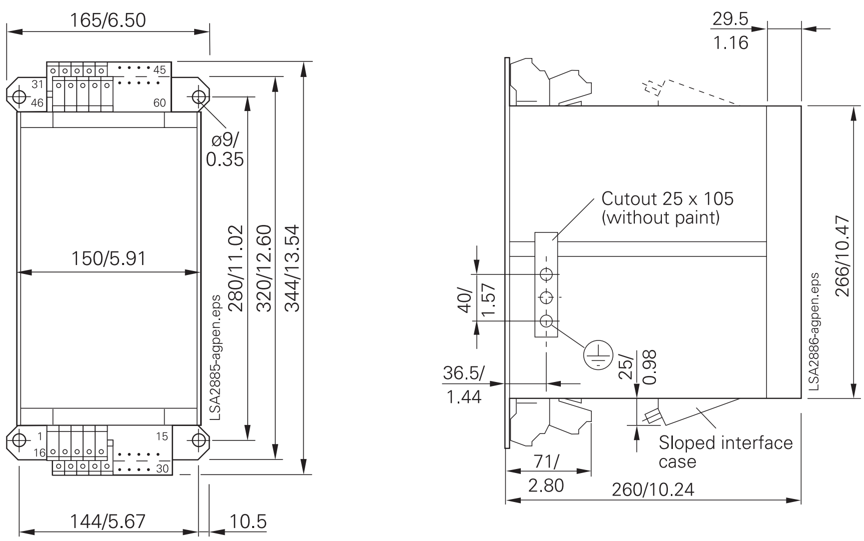
Side view

Rear view 1
7SA610, 7SD61, 7SJ64

Rear view 2
7SJ61, 7SJ62, 7UT612,
7UM611

Panel cutout

Fig. 16/22
Housing for panel flush mounting/
cubicle mounting (1/3 x 19")



Front view

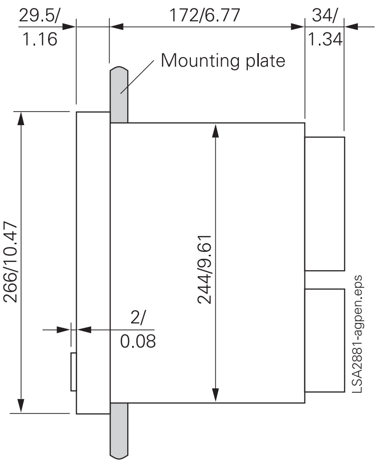
Side view

Fig. 16/23
1/3 x 19" surface-mounting housing

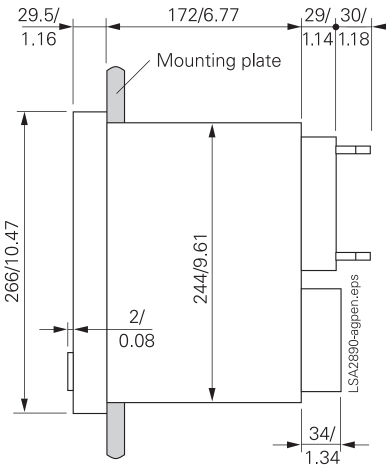
16

Dimension drawings in mm / inch

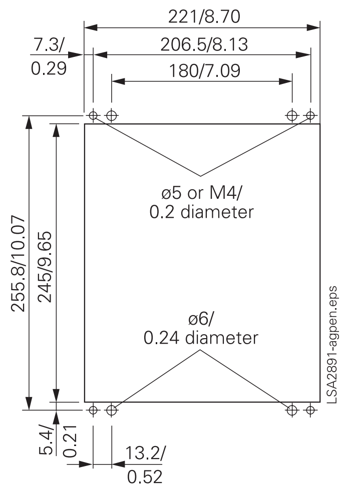
Dimension drawings for SIPROTEC 4
1/2 x 19" flush-mounting housings (7XP20)



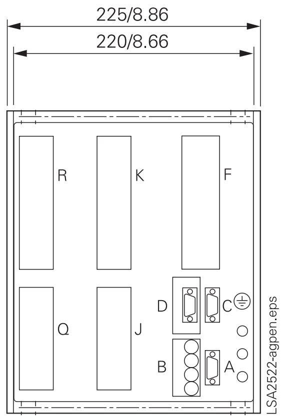
Side view 1



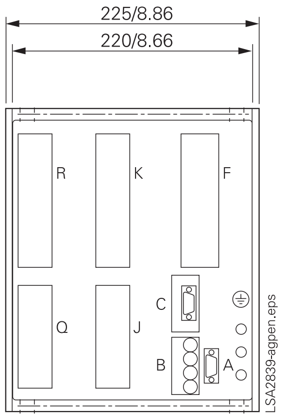
Side view 2



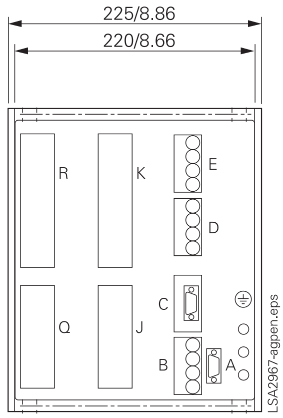
Panel cutout



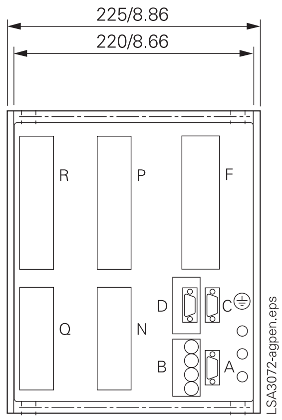
Rear view 1
7SA61/63, 7UM621, 7UM623
7SJ64



Rear view 2
7SJ63, 7UM612



Rear view 3
7SA522, 7SD52/53



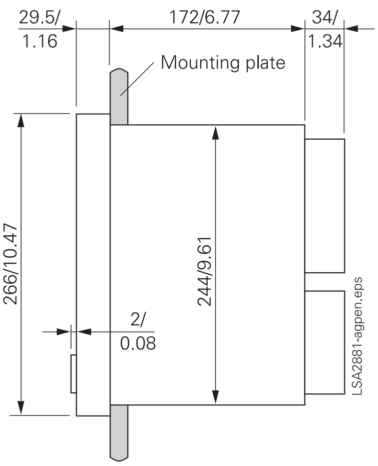
Rear view 4
7UT613

Fig. 16/24
1/2 x 19" flush-mounting housing

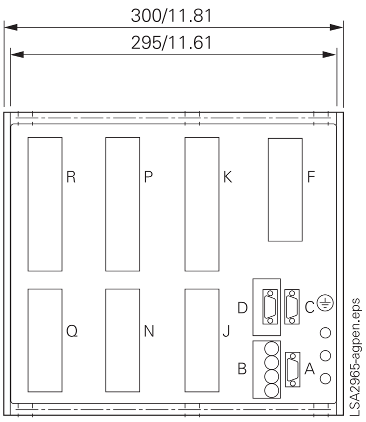
16

Dimension drawings in mm / inch

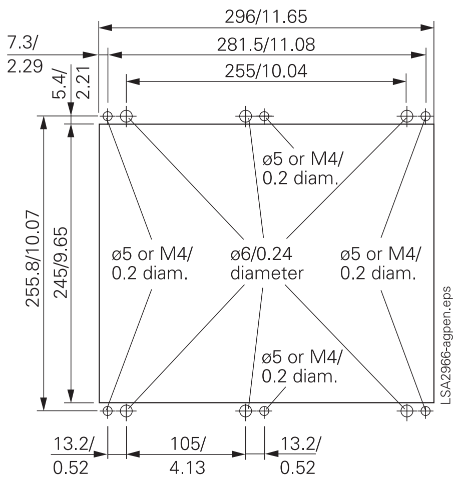
Dimension drawings for SIPROTEC 4
2/3 x 19" flush-mounting housings (7XP20)



Side view



Rear view



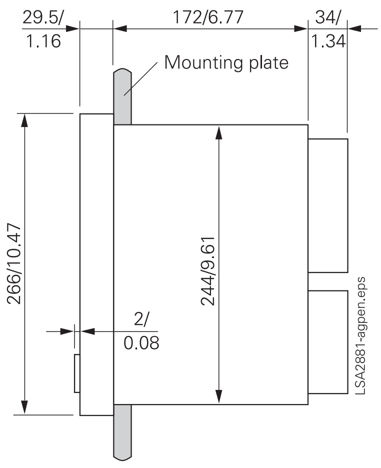
Panel cutout

Fig. 16/25
2/3 x 19" flush-mounting housing for 7SA613

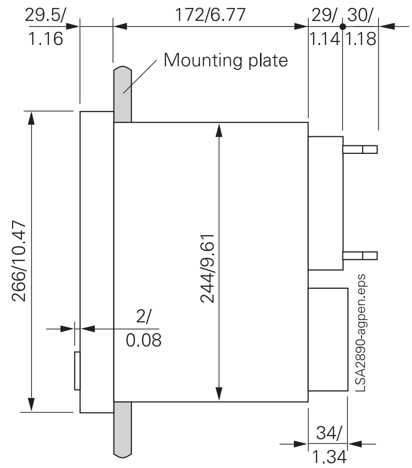
16

Dimension drawings in mm / inch

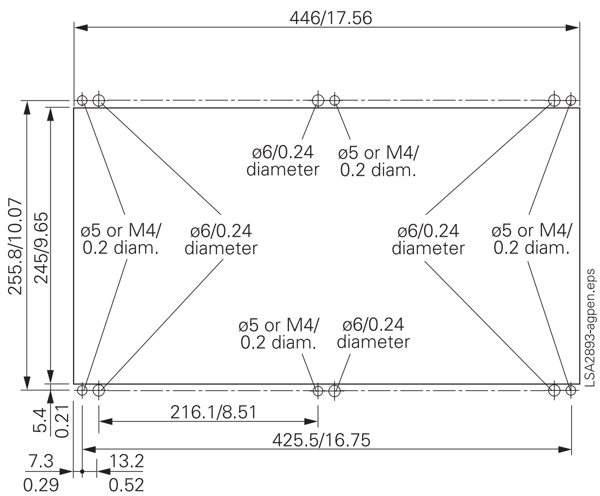
Dimension drawings for SIPROTEC 4
1/1 x 19" flush-mounting housings (7XP20)



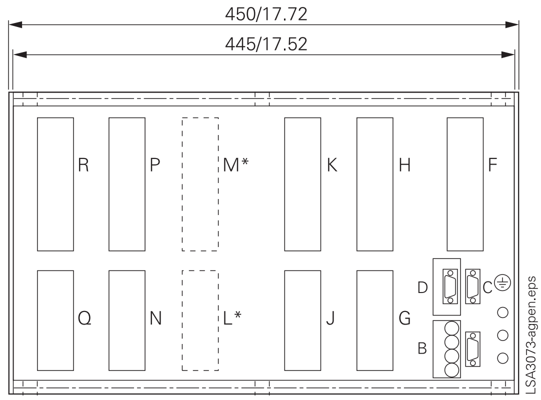
Side view 1



Side view 2

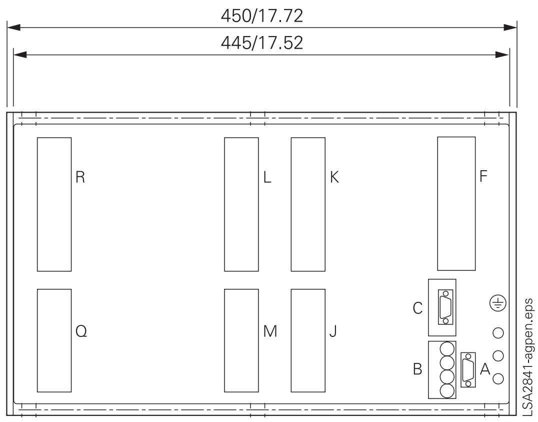


Panel cutout

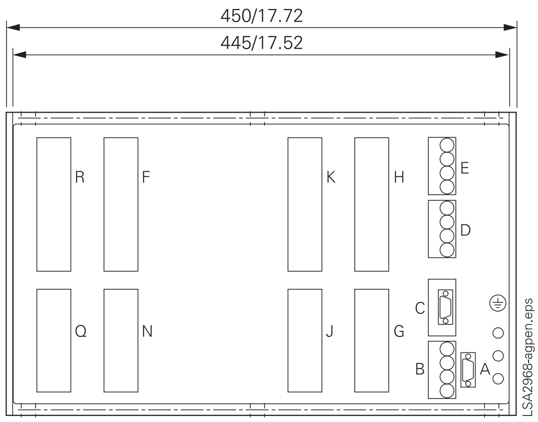


* Terminals M and L additionally for 7UT635 only

Rear view 1
7SA6, 7UM622, 7SJ64, 7UT633, 7UT635



Rear view 2
7SJ63, 6MD63

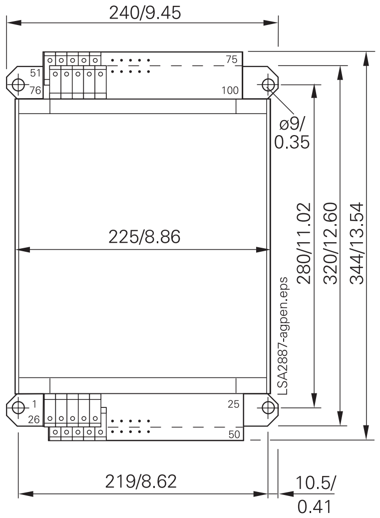


Rear view 3
7SA522, 7SD52/53

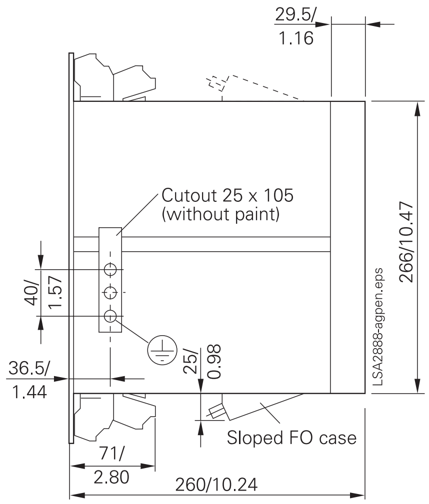
Fig. 16/26
in 1/1 x 19" flush-mounting housing

Dimension drawings in mm / inch

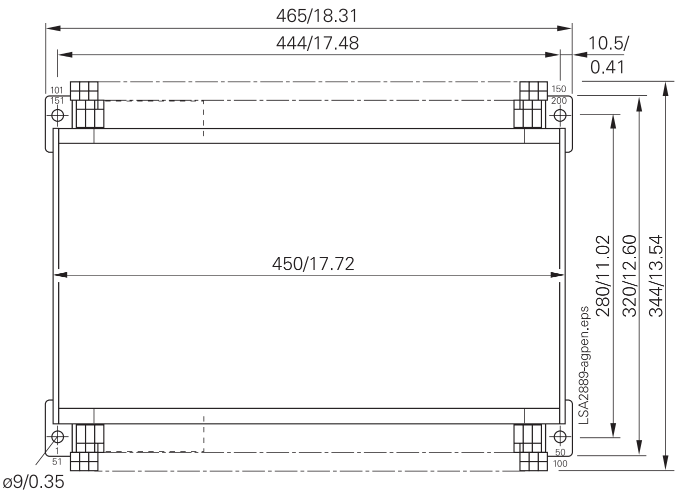
Dimension drawings for SIPROTEC 4
1/2 and 1/1 x 19" surface-mounting housings
(7XP20)



Front view
1/2 x 19" surface-mounting
housing 7XP20



Side view

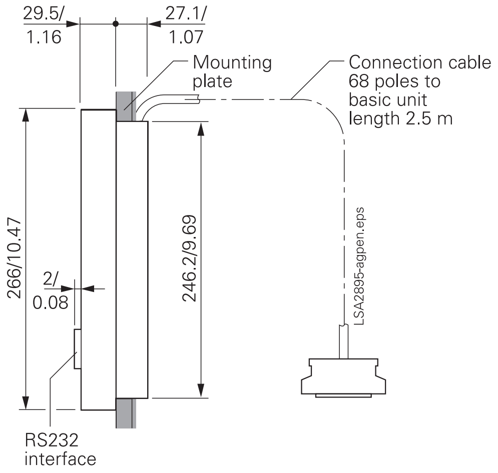


Front view
1/1 x 19" surface-mounting housing 7XP20
(without sloped FO case)

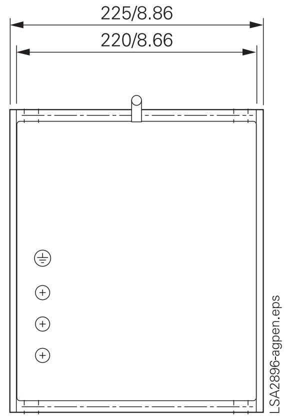
Fig. 16/27
1/2 and 1/1 x 19" surface-mounting housing

Dimension drawings in mm / inch

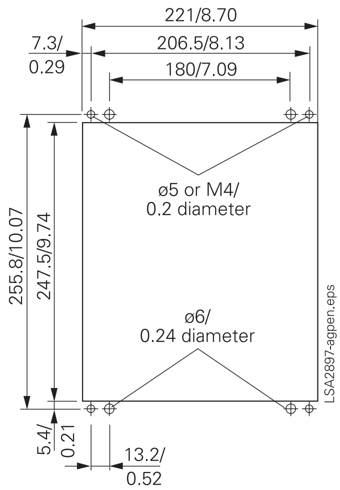
Dimension drawings for SIPROTEC 4
1/2 and 1/1 x 19" housings
with detached operator panel



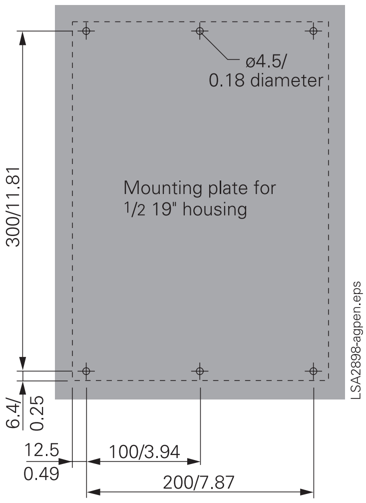
Detached operator panel (side view)

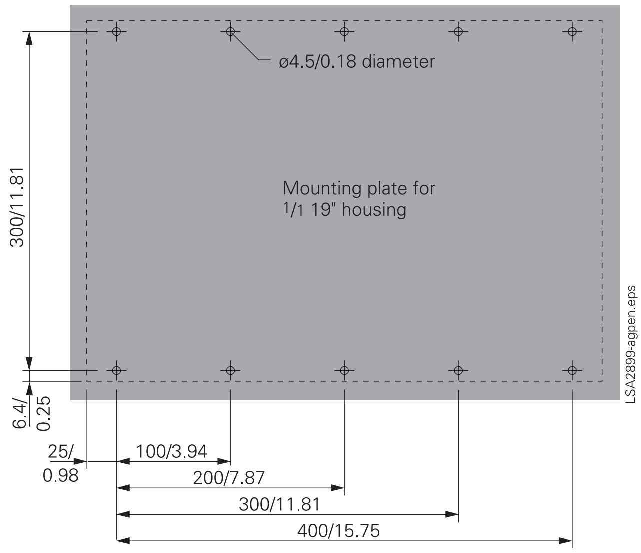


Rear view



Panel cutout





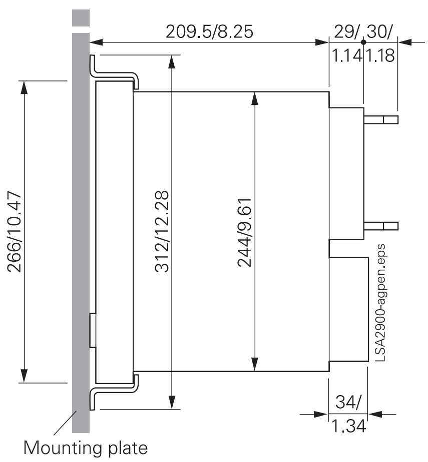
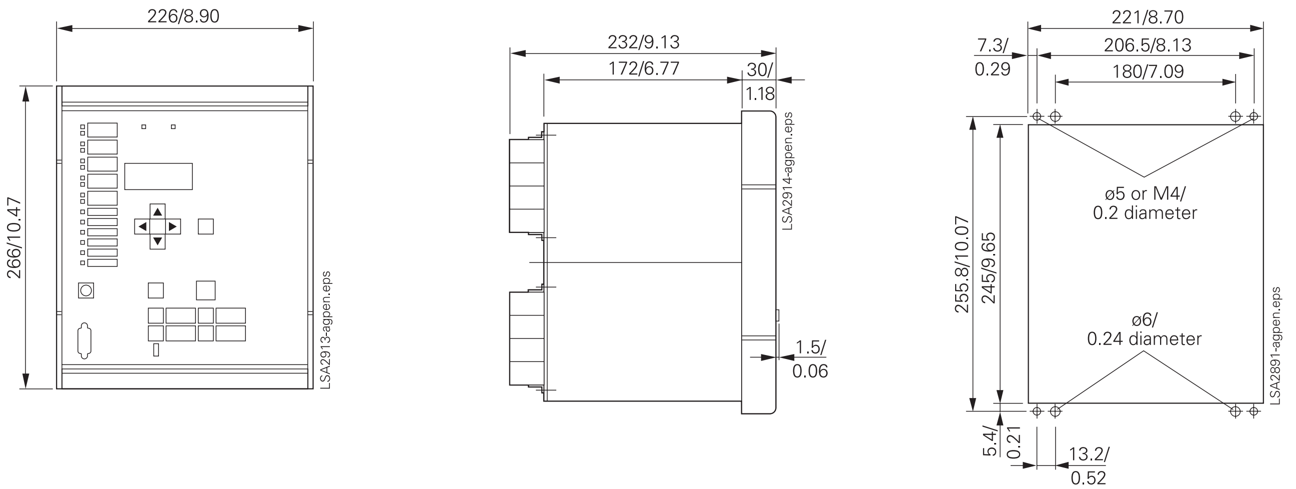


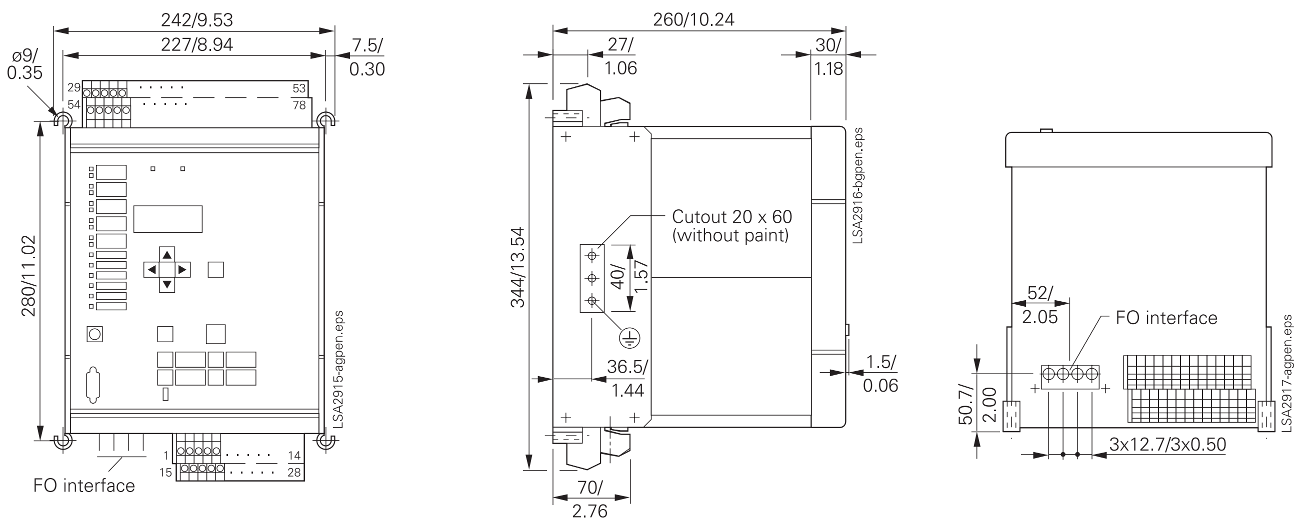
Fig. 16/28
Housing with detached or no operator panel

Dimension drawings in mm / inch



Front view Side view Panel cutout

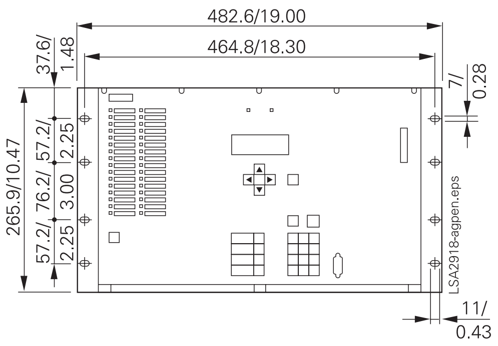
Fig. 16/29
7SS52 bay unit in 7XP2040-2 housing
for panel flush mounting/cubicle mounting



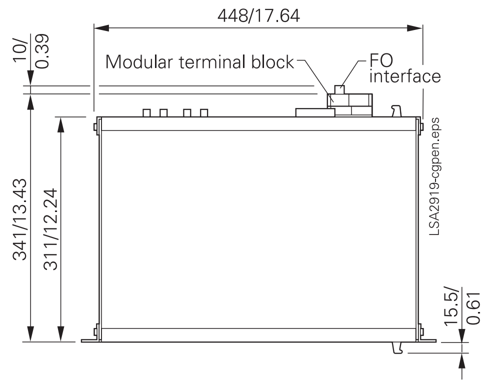
Front view Side view View from below

Fig. 16/30
7SS523 bay unit in 7XP2040-1 housing for
panel surface mounting

Dimension drawings in mm / inch

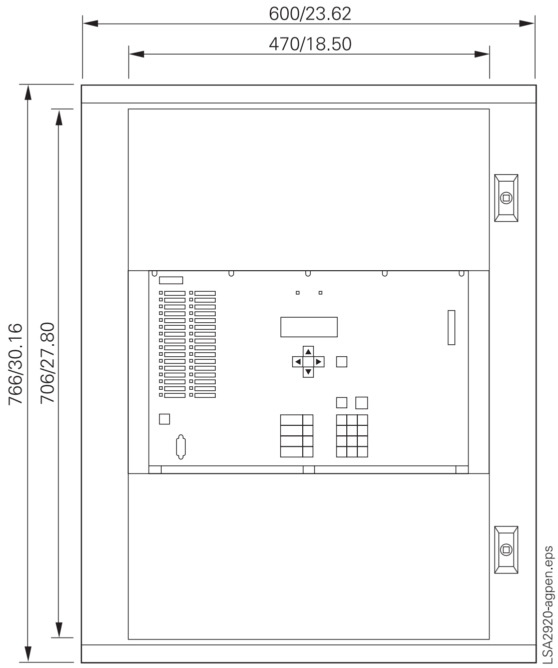


Front view

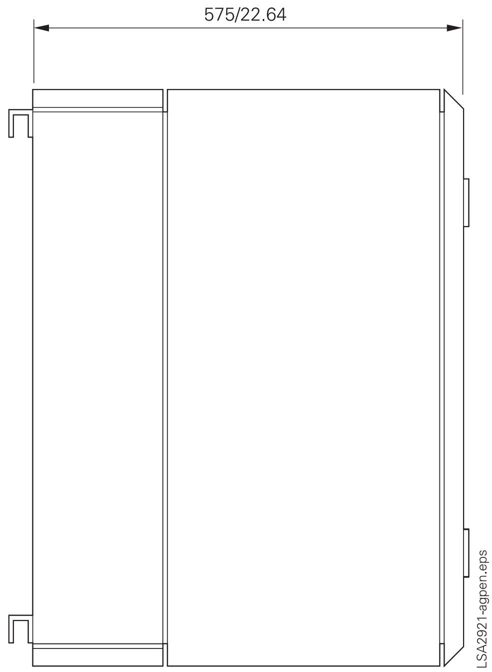


Top view

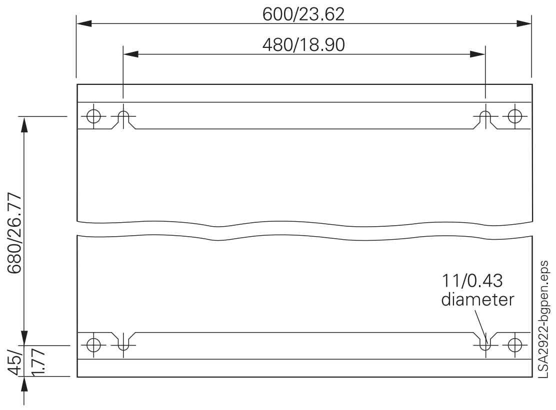
Fig. 16/31
7SS522 central unit in SIPAC subrack



Front view



Side view



Rear view

Fig. 16/32
7SS522 central unit with housing for wall mounting

Dimension drawings in mm / inch

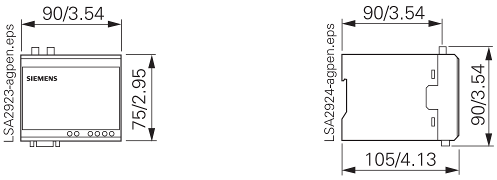


Fig. 16/33
Converter devices for rail mounting

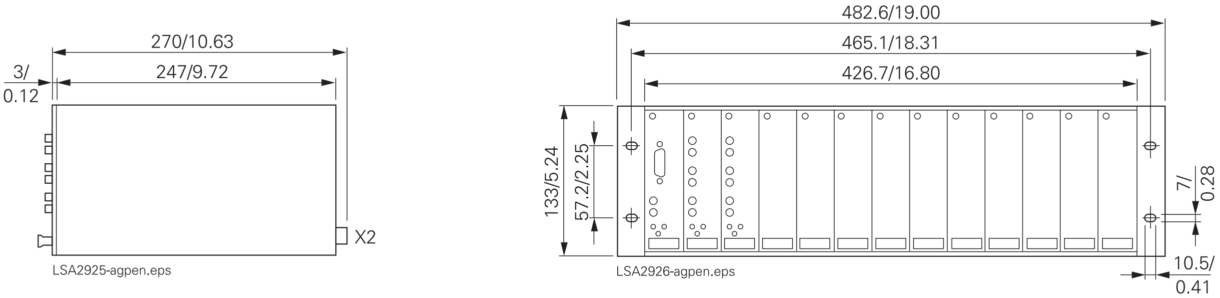


Fig. 16/34
7XV5300 star coupler in 19" subrack

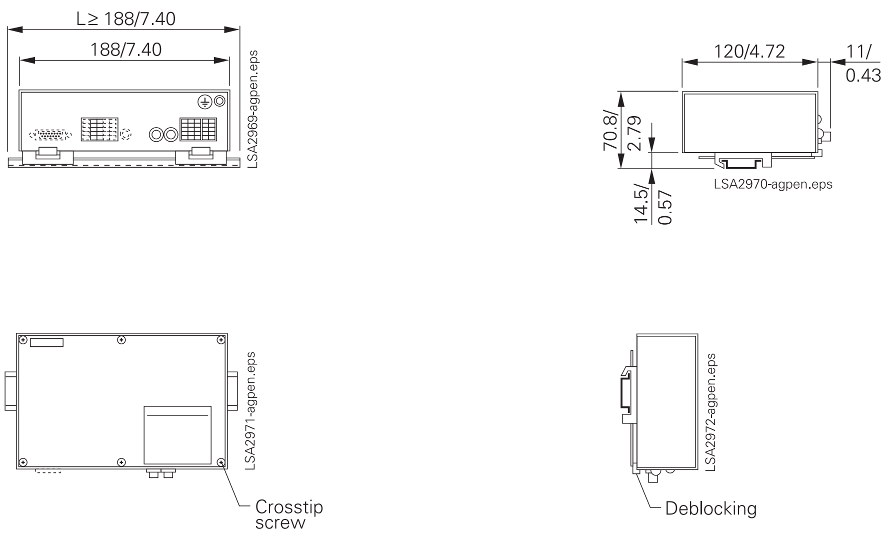
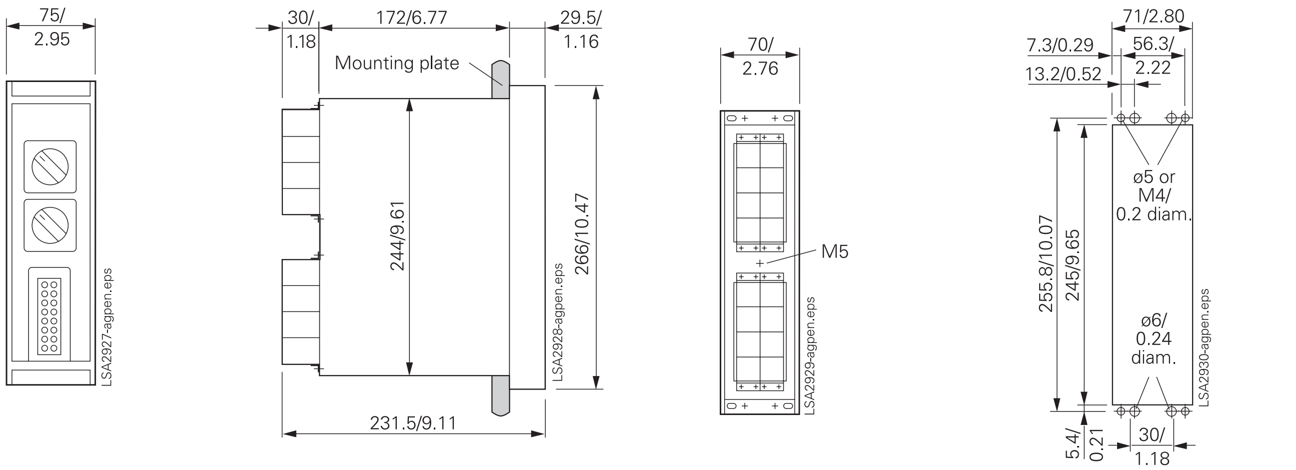


Fig. 16/35
7XV5662 communication converter

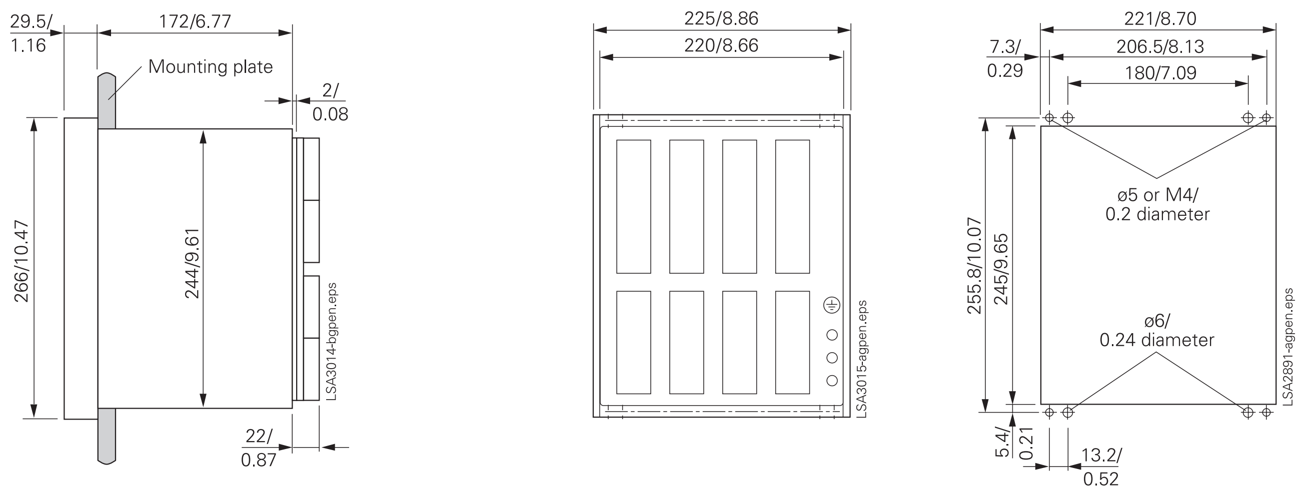
16

Dimension drawings in mm / inch



Front view Side view Rear view Panel cutout

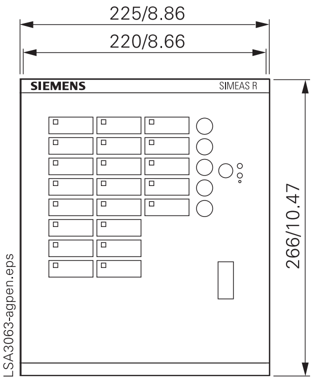
Fig. 16/36
7XV75 with housing 7XP2020-2
(for panel flush mounting)

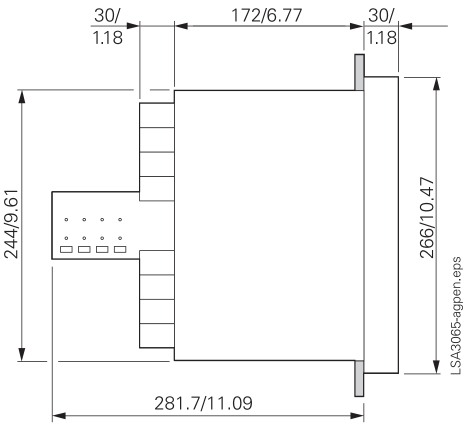


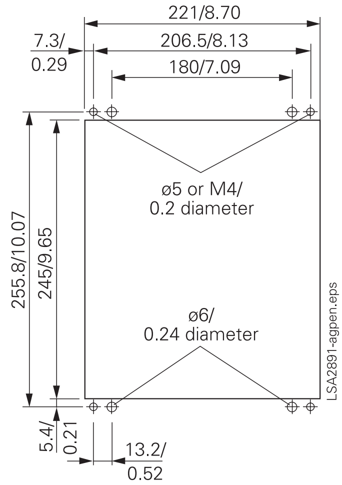
Side view Rear view Panel cutout

Fig. 16/37
Housing 7XP204 of the peripheral modules (7SS60)
for panel or cubicle flush mounting

Dimension drawings in mm / inch





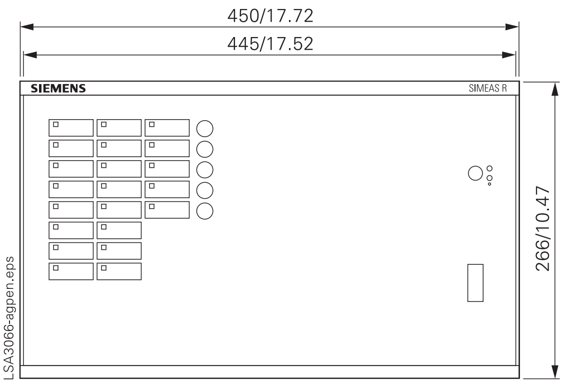


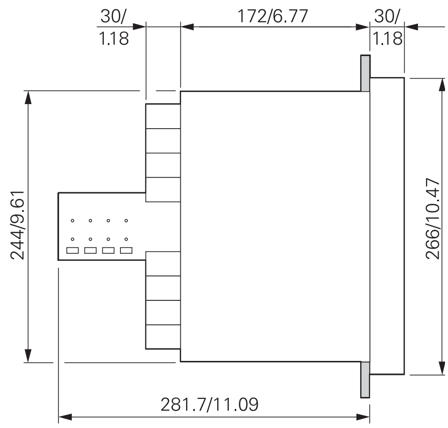
Front view

Side view

Panel cutout

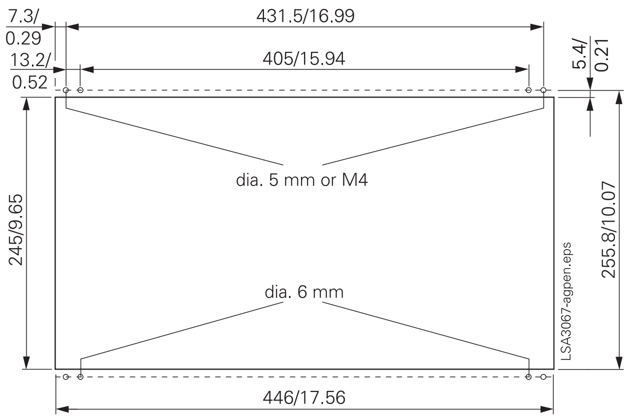
Fig. 16/38
7KE6000 SIMEAS R
1/2 x 19" with 7XP20 housing for panel flush mounting





Front view

Side view

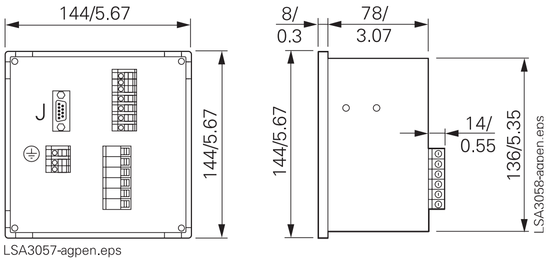


Panel cutout

Fig. 16/39
7KE6000-1 SIMEAS R
1/1 x 19" unit in 7XP20 housing
for panel flush mounting

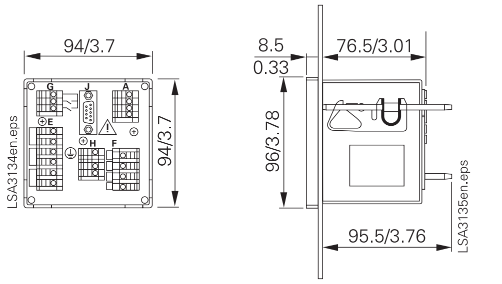
16

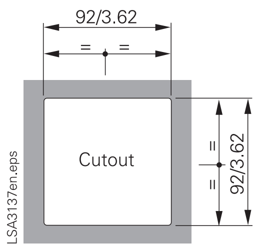
Dimension drawings in mm / inch

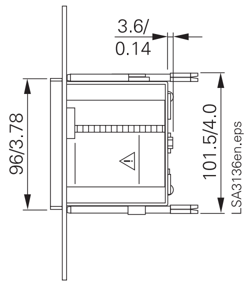


7KG7000 SIMEAS P

Fig. 16/40

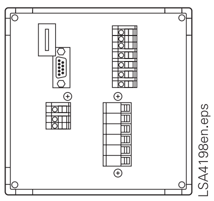




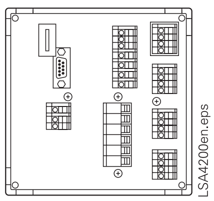


SIMEAS P50

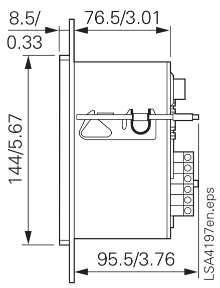
Fig. 16/41



SIMEAS P500/P600



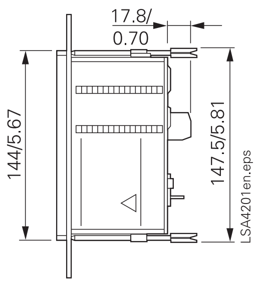
SIMEAS P610



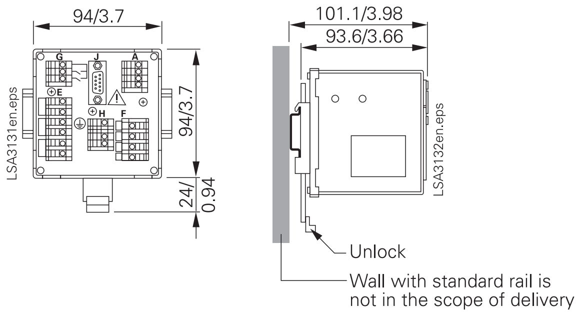
SIMEAS P500/P600/P610

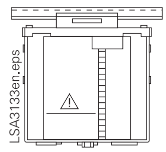
Attention:
Depending on the cable cross-section a minimal bend radius has to be considered.

Fig. 16/42



SIMEAS P500/P600/P610

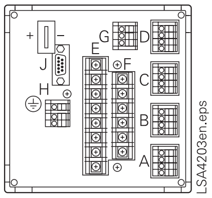




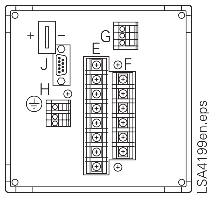
SIMEAS P55

Fig 16/43

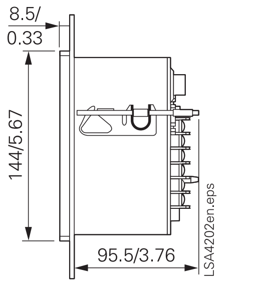
Dimension drawings in mm / inch



SIMEAS P660

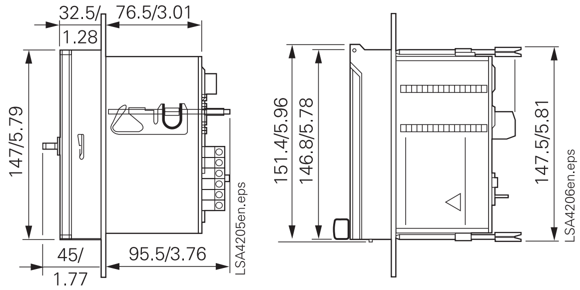


SIMEAS P550/P650



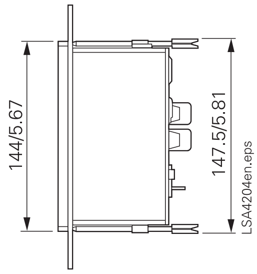
SIMEAS P550/P650/P660

Fig. 16/44

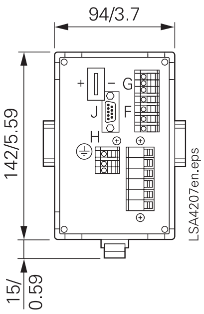


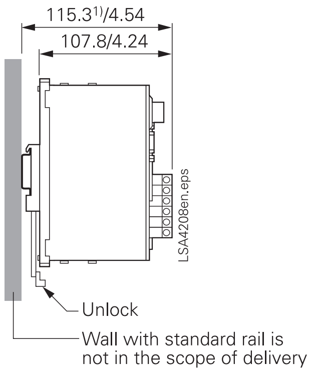
SIMEAS P5xx/P6xx
with transparent plastic facia IP54

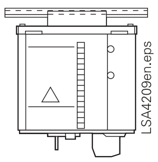
Fig. 16/45



SIMEAS P550/P650/P660



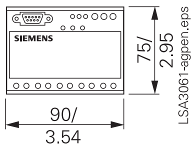




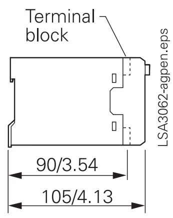
SIMEAS P100/P200

Fig. 16/46

1) Dimension illustration valid for standard rail according DIN EN 50022 - 35 x 7.5 mm



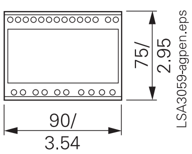
Front view



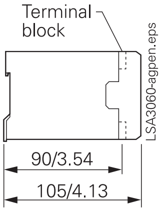
Side view

7KG8000 SIMEAS Q

Fig. 16/47



Front view



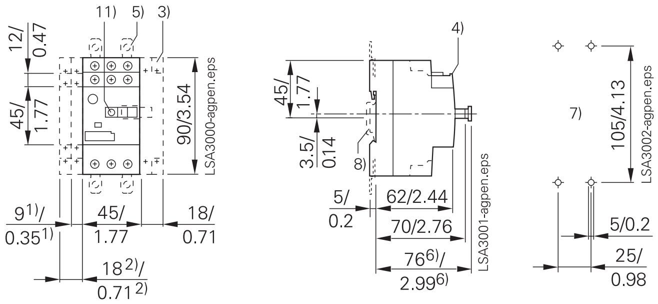
Side view

7KG6000 SIMEAS T

Fig. 16/48

16

Dimension drawings in mm / inch



7RV16 circuit-breaker
Fig. 16/49

1) Auxiliary switch, 2-pole, located on the side.
2) Auxiliary switch, 4-pole, located on the side.
3) Auxiliary release.
4) Auxiliary switch transverse position.
5) Link for screw fixing.
6) Only with undervoltage release combined with leading auxiliary switch.
7) Drilling diagram.
8) Monitoring rail 35 mm, acc. to EN 50022.
11 Lockable in OFF position with padlock, bracket diameter 3.5 to 4.5 mm

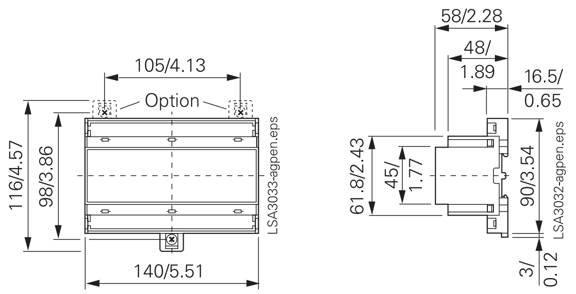


Fig. 16/50
Temperature monitoring box

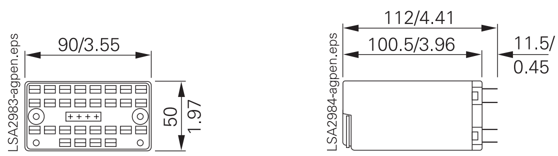


Fig. 16/51
7PA22, 7PA26 auxiliary relays

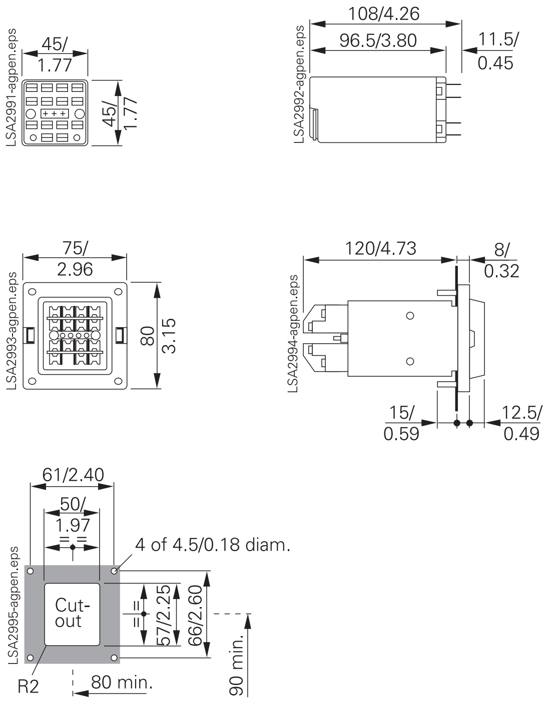


Fig. 16/52
7PA23 auxiliary relay +
flush mounting socket 7XP9011-1

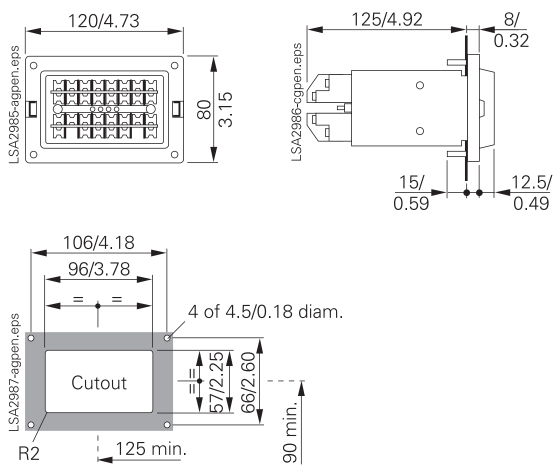


Fig. 16/53
Flush mounting socket 7XP9010
for 7PA22, 7PA26 auxiliary relays
7TS16 indication relay
7PA30 three-phase trip circuit supervision

16

Dimension drawings in mm / inch

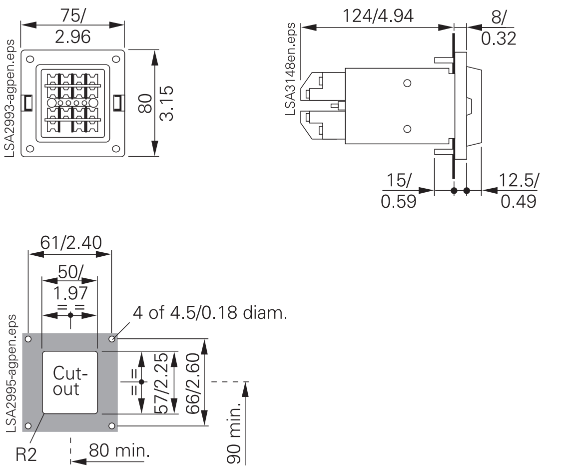


Fig. 16/54
Flush mounting socket 7XP9011-0-1
for 7PA23 auxiliary relay
7PA30 trip single-phase circuit supervision

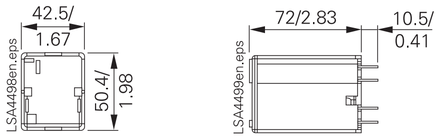


Fig. 16/55
7PA27

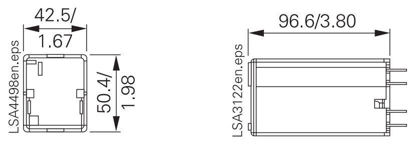
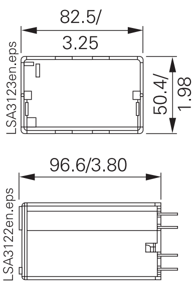


Fig. 16/56
7PA30 single-phase



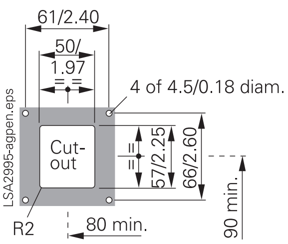


Fig. 16/57
7TS16, 7PA30 three-phase

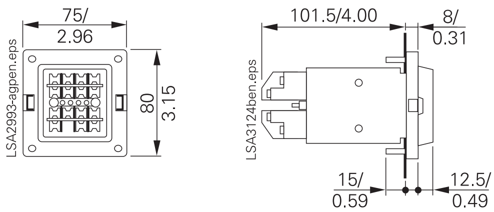


Fig. 16/58
Flush mounting socket 7XP9011-2
for 7PA27 auxiliary relay

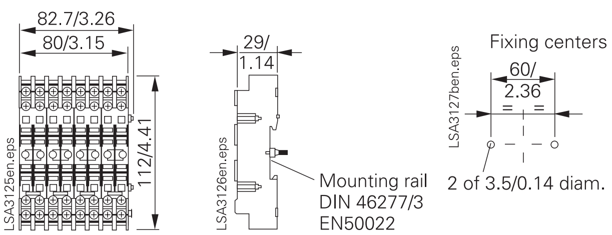


Fig. 16/59
Surface mounting socket 7XP9012
7PA22, 7PA26 auxiliary relays
7TS16 indication relay
7PA30 three-phase trip circuit supervision

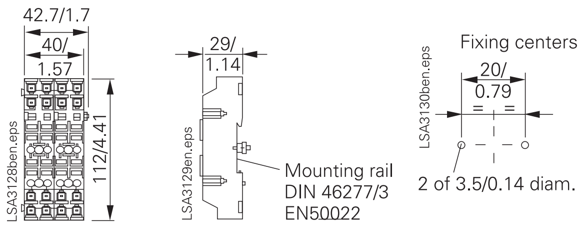


Fig. 16/60
Surface mounting socket 7XP9013
for 7PA23/27 auxiliary relay
7PA30 single-phase trip circuit supervision

Assignment for new products

Products applied until now	Function	Recommended new products
7PA10	Auxiliary relay	7PA26/27
7PA20	Lockout relay	7PA22/23
7PA21	Trip circuit monitoring	7PA30
7RP72	Frequency relay	7RW600
7SD24	Line differential relay	7SD600
7SD510/511	Line differential relay via FO	7SD610
7SD512	Line differential relay via FO	7SD5
7SA500	Distance protection	7SA6, 7SA522
7SA501	Distance protection	7SA6, 7SA522
7SA502	Distance protection	7SA6, 7SA522
7SA510	Distance protection	7SA6, 7SA522
7SA511	Distance protection	7SA6, 7SA522
7SA513	Distance protection	7SA6, 7SA522
7SJ41	Overcurrent relay	7SJ45
7SJ50	Overcurrent relay	7SJ600/602
7SJ510	Overcurrent relay	7SJ61
7SJ511	Overcurrent relay	7SJ61
7SJ512	Overcurrent relay	7SJ62
7SJ531	Overcurrent relay	7SJ63
7SN71	Transient earth fault relay	7SN600
7SV72	Power supply unit	7SV73
7UT512	Transformer differential relay	7UT612
7UT513	Transformer differential relay	7UT613/7UT63
7UM51	Machine protection	7UM61/62
7TS15	Annuciation relay	7TS16
7SS51	Busbar protection	7SS52
7SS13	Busbar protection	7SS60
7VH80/83	High-impedance diff. protection	7VH60
7SV50	BF relay	7SV600
7SV512	Breaker failure relay	7VK61
7VK512	Auto-reclosure und synchronism check relay	7VK61
7XV72	Test switch	7XV75
7VP48	Test equipment	7VP15
7XS50	DIGSI operating program	7XS54

Order No. Index

Order No. Index

Training

Equipment reliability and availability are essential for all owners and users. At the same time, maintenance costs need to be kept to a minimum. The liberalization of energy markets presents new challenges to all; maintaining and enhancing competitive strength are among today's most important business goals. Investment in technical plants and human resources enables these goals to be realized. Innovations in the technical field confront the users with the need of establishing, maintaining and extending their qualification and know-how. Our training programs are tailored to meet your specific needs. With our know-how, we can help you to keep ahead.

Our training centers offer training programs comprising an extensive range of courses covering all the important aspects of numerical protective relaying. Choosing our courses will simplify your planning and ensure you of high-quality professional instruction at a reasonable cost. It is also possible to arrange training on your own premises thereby reducing costs for group participation. We will jointly plan a complete training program that matches your business goals and your particular working context.

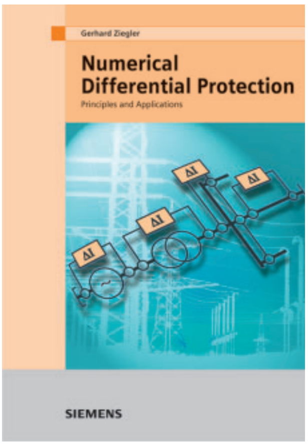
Each course and the corresponding training documents are available in many languages. On the Internet at www. ptd-training.com you will find our complete training program with details of contents, dates, costs and contacts.

16

Books and publications

Books on protection

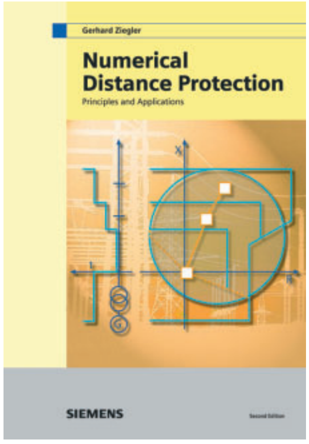
A textbook and standard work in one, these books cover all topics, which have to be paid attention to for planning, designing, configuring and applying differential and distance protection systems. The books are aimed at students and engineers who wish to familiarize themselves with the subject of differential/distance substation protection, as well as the experienced user, entering the area of numerical differential/distance protection. Furthermore, they serve as a reference guide for solving application problems.



LSP2811.tif

Siemens Order No.
A19100-L531-B884-X-7600

ISBN 3-89578-234-3



LSP2812.tif

Siemens Order No.
A19100-L531-B917-X-7600

ISBN 3-89578-266-1

Applications and Case Studies Brochures for SIPROTEC Protection Relays

On 224 pages the "Applications-brochure" describes 26 protection applications ranging from line protection to busbar protection.

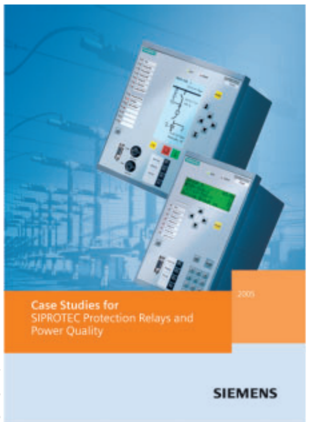
Detailed examples are given of the wide and flexible scope of application of SIPROTEC protection relays.

If you wish to know more about carried-out power system and generator projects involving SIPROTEC protection relays as well as realized power quality projects, then our "Case Studies brochure" is the right source to turn to.

Please contact your Siemens representative for free copies by indicating the Order No.

LSP2813.tif

Order No.
E50001-K4451-A101-A1-7600



LSP2814.tif

Order No.
E50001-K4451-A101-A1-7600

Multimedia CD ROMs

Useful information on selection and applications for the SIPROTEC protection relays is provided for the user.

The following subject matters are available on individual CD ROMs:

– SIPROTEC relay features
– SIPROTEC application hints
– Communication based on IEC 61850
– DIGSI Software operating program
– SIGRA Software evaluation of fault records

Some CD ROMs can be used as tutorials for computer-based training.

Ask your Siemens representative for the CDs free of charge.

List of available multimedia CD ROMs

Title	Order No.
SIPROTEC Catalog 2006	E50001-D4400-A7-A4-7600
SIPROTEC 4 you – Features, Applications, Relays	E50417-A1174-C281-A1
SIPROTEC 4 you – Start up	E50417-A1174-C215-A1
SIPROTEC 4 you – IEC 61850 & Ethernet	E50001-U321-A213-CD2-7600
DIGSI 4 you – Partner for Life	E50417-A1174-C328-A1
DIGSI 4 you – Start up	E50417-A1174-C329-A1
SIGRA 4 you – Start up	E50417-A1174-C341-A1

Siemens Companies and Representatives of the Power Transmission and Distribution Group

Europe

Austria
Siemens AG Österreich
Gudrunstr. 11
A-1101 Wien
Phone: +43-5-1707-46530
Fax: +43-5-1707-53075

Belarus (White Russia)
Siemens Representative Office
ul. Storozhovskaja 8
220002, Minsk
Phone: +375-17-217-3484
Fax: +375-17-210-0395

Belgium
Siemens S.A.
Demeurslaan 132
B-1654 Huizingen
Phone: +32-2-536-7789
Fax: +32-2-536-6900

Bosnia and Herzegovina
Siemens PTD
Hamdije Cemerlica 2
BA-71000 Sarajevo
Phone: +387-33-276 647
Fax: +387-33-661 279

Bulgaria
Siemens PTD
2, Kukush Str.
BG-1309 Sofia
Phone: +359-2-8115 635
Fax: +359-2-8115 622

Croatia
Siemens PG/PTD
Zagrebacka 143a
HR-10000 Zagreb
Phone: +385-1-6105 378
Fax: +385-1-6040 632

Czech Republic
Siemens s. r. o.
Evropska 33a
CZ-160 00 Praha
Phone: +420-2-3303 2132
Fax: +420-2-3303 2190

Denmark
Siemens A / S
Borupvang 3
DK-2750 Ballerup
Phone: +45-4477 4477
Fax: +45-4477 4034

Finland
Siemens Osakeyhtiö
Majurinkatu 6
FIN-02600 Espoo
Phone: +358-10-511 3385
Fax: +358-10-511 3770

France
Siemens S. A.. S.
9, boulevard Finot
F 93527 Saint Denis, Cedex 2
Phone: +33-1-4922 3972
Fax: +33-1-4922 3091

Greece
Siemens A. E.
Artemidos 8
GR-151 25 Amaroussio/Athen
Phone: +30-210-6864 771
Fax: +30-210-6864 536

Siemens A. E. North
Georgikis Scholis 89
GR-570 01 Thessaloniki
Phone: +30-2310-479 217
Fax: +30-2310-479 265

Hungary
Siemens Rt.
Gizella út 51-57
H-1143 Budapest
Phone: +36-1-471 1668
Fax: +36-1-471 1632

Italy
Siemens S.p. A.
Via Vipiteno 4
I-20 128 Mailand
Phone: +39-02-243 62566
Fax: +39-02-243 64815

Ireland
Siemens Ltd.
Leeson Close
Dublin 2
Phone: +353-1-216 2423
Fax: +353-1-216 2458

Netherlands
Siemens Nederland N.V.
Prinses Beatrixlaan 800
NL-2595 BN Den Haag
Phone: +31-70-333 3975
Fax: +31-70-333 3225

Norway
Siemens A / S
Bratsberg veien 5 - Bygg 6
N-7493 Trondheim
Phone: +47-7395 9132
Fax: +47-7395 9790

Poland
Siemens Sp.z.o.o. North
ul. Zupnicza 11
PL-03-821 Warschau
Phone: +48-22-870 9127
Fax: +48-22-870 8627

Siemens Sp.z.o.o. South
ul. Gawronow 22
PL-40-533 Katowice
Phone: +48-32-208 4250
Fax: +48-32-208 4259

Portugal
Siemens S. A.
Rua Irmaos Siemens
1-Alfagide
P-2720-093 Amadora
Phone: +351-21-417 8361
Fax: +351-21-417 8071

Romania
Calea Plevnei nr.139
Sector 6
RO 060011 Bucuresti
Phone: +40-21-2077 390
Fax: +40-21-2077 482

Russia
OOO Siemens, PTD
ul. Letnikovskaja, 11/10
115114, Moscow
Phone: +7-095-737 1815
Fax: +7-095-737 2385

Serbia and Montenegro
Siemens PTD
Omladinskih brigade 21
CS-11070 Beograd
Phone: +381-11-2096 185
Fax: +381-11-2096 055

Slovakia
Siemens PTD EA
Stromová 9
SK-837 96 Bratislava
Phone: +421-2-5968 2660
Fax: +421-2-5968 5260

Slovenia
Siemens PG PTD
Bratislavska cesta 5
SI-1511 Ljubljana
Phone: +368 (1) 4746-116
Fax: +386 (1) 4746-106

Spain
Siemens S.A.
Ronda de Europa
5-Tres Cantos
E 28 760 Madrid
Phone: +34-91-514 7545
Fax: +34-91-514 4730

Switzerland
Siemens-Schweiz AG
Freilagerstr. 28
CH-8047 Zürich
Phone: +41-585-585 051
Fax: +41-585-544 761

Turkey
Siemens Sanayi ve Ticaret AS
Yakacik Yolu No: 111
34870 Kartal-Istanbul
Phone: +90-216-459 2721
Fax: +90-216-459 2682

Ukrainia
DP Siemens Ukraine
ul. Predslawynska 11-13
03150, Kiev
Phone: +380-44-201 2300
Fax: +380-44-201 2301

United Kingdom
Siemens plc
Sir William Siemens House
Princess Road
Manchester M20 2UR
Phone: +44-161-446 6634
Fax: +44-161-446 6476

Africa

Ethiopia
Siemens (Pvt) Ltd.
Africa Avenue (Bole Road)
Friendship city center 7th Floor
P.O.Box 5505
Addis Ababa
Phone: +251-11-563 9922
Fax: +251-11-563 9998

Egypt
Siemens Ltd.
Cairo, P.O.Box 775 / 11511
55 El Nakhil and El Aenab St.
El-Mohandessin, Giza
Phone: +20-2-333 3644
Fax: +20-2-333 3608

Kenia
IET, Rep. of Siemens AG
Unit 90, The Alpha Centre
Mombasa Road
P.O.Box 46215
Nairobi
Phone: +254-2-35 1082
Fax: +254-2-35 0469

Morocco
Siemens S.A.
Km1, Route de Rabat
Ain-Sebâa
20250 Casablanca
Phone: +212-22-351 025
Fax: +212-22-240 151

Nigeria
Siemens Ltd.
98/100 Oshodi /
Apapa Expressway
Lagos
Phone: +234-1-4500 137
Fax: +234-1-4500 131

South Africa
Siemens Ltd., PTD EA
300 Janadel Avenue
Halfway House
Midrand 1685
Phone: +27-11-652 2953
Fax: +27-11-652 2474

Uganda
IET, Rep. of Siemens AG
Plot 33/35, Kibira Road
Ind. Area
P.O.Box 23881
Kampala
Phone: +256-41-251 105
Fax: +256-41-251 107

North America

USA
Siemens PT&D, Inc.
7000 Siemens Rd.
Wendell, NC 27591-8309
Phone: +1-800-347 6657
+1-919-365 2196
Fax: +1-919-365 2552
Internet: www.siemenstd.com

Canada
Siemens Canada Ltd.
SIS Service, PT&D
1550 Appleby Line
Burlington, ON L7L 6X7
Phone: +1-905-315 6868
ext. 7223
Fax: +1-905-315 6997

Central America

Costa Rica
Siemens S.A.
P.O.Box 10022-1000
La Uruca
200 Este de la Plaza
San José
Phone: +506-287 5120
Fax: +506-233 5244

Mexico
Siemens S.A. DE C.V.
Poniente 116, no. 590
Col. Ind. Vallejo
Delegacion Azcapotzalco
02300 Mexico D.F.
Phone: +52-5-328 2031
Fax: +52-5-328 2192

South America

Argentina
Siemens S.A.
Julio A. Roca 516
Capital Federal
C1067ABN Buenos Aires
Phone: +54-11-4738 7194
Fax: +54-11-4738 7355

Brazil
Siemens Ltd.
Av. Mutinga, 3800
Cap. 05110-901 Sao Paulo
Phone: +55-11-3908 3912
Fax: +55-11-3908 3988

Chile
Av. Providencia 1760
Edificio Palladio, Piso 10
Providencia
150-0498 Santiago de Chile
Phone: +56-2-477 1317
Fax: +56-2-477 1030

Columbia
Siemens S.A.
Santafe de Bogota,D.C.
Carrera 65 No. 11-83
Apartado 8 01 50
Conmuta
Santaféde Bogotá6
Phone: +57-1-294 2272
Fax: +57-1-294 2500

El Salvador
Siemens S.A., Energia
Antiguo Cuscatlán,
Apartado 1525
CP 1137 San Salvador
Phone: +503-278 3333
Fax: +503-278 3334

Equador
Siemens S.A. PTD-PG
Calle Manuel Zambrano
y Panamericana North KM2.5
Quito
Phone: +593-2-294 3971
Fax: +593-2-294 3904

Guatemala
Siemens Electrotécnica S.A. PTD
2a. Calle 6-76, Zone 10
Ciudad de Guatemala
Phone: +502-379 2393
Fax: +502-334 3670

Peru
Siemens S.A.C., PTD
Avenida Domingo
Orue 971
Lima
Phone: +51-1-215 4450
Fax: +51-1-421 9292

Venezuela
Siemens S.A., PTD EA
Avenida Don Diego Cisneros/
Urbanización Los Ruices
Caracas 1071
Phone: +58-212-203 8755
Fax: +58-212-203 8200

Asia Pacific

Australia
Siemens Ltd., PTD-EA
885 Mountain Highway
Bayswater VIC 3153
Phone: +613-9721 7360
Fax: +613-9721 7319

Bangladesh
Siemens Ltd., PTD
Plot 02, Block SW (1)
Gulshan Avenue
Dhaka –1212
Phone: +88-02-989 3536
Fax: +88-02-989 2439

China
Siemens Ltd., PTD
No. 7, Wangjing Zhonghuan
Nanlu, Chaoyang District
Beijing, 100 102
Phone: +86-10-6472 1888
ext. 3149
Fax: +86-10-6472 1464

Hong Kong
Siemens Ltd., PTD
58/F Central Plaza
18 Harbour Road
Wanchai, Hong Kong
Phone: +852-25 83 3362
Fax: + 852-28 02 9908

India
Siemens Ltd., PTD
6A Maruti Industrial Area
Sector-18
Haryana 12201 Guragon
Phone: +91-124-234 9359
Fax: +91-124-234 5346

Indonesia
Siemens Indonesia, PTD S
Jalan Jendral Ahmad
Yani Kav. B67-68
Jakarta, Pulo Mas 13210
Phone: +62-21-472 9153
Fax: +62-21-471 5055

Japan
Siemens K.K.
20-14, Higashi-Gotanda
3-chome, Shinagawa-ku
Tokyo 141-8641
Phone: +81-3-5423 6814
Fon: +81-3-5423 8727

Siemens Companies and Representatives of the Power Transmission and Distribution Group *(continued)*

Kazakhstan
TOO Siemens, PTD
Dostyk Ave. 117/6
050059, Almaty
Phone: +7-3272-58 37 37
Fax: +7-3272-58 37 00

Korea
Siemens Ltd.
10th Floor Asia Tower Bldg
726, Yeoksam-dong,
Kangman-gu
Seoul 135-719, Korea
Phone: +82-2-3450 7347
Fax: +82-2-3450 7359

Malaysia
Siemens
Electrical Engineering Sdn Bhd
13th Floor, CP Tower
11 Section 16/11,
Jalan Damansara
46350 Petaling Jaya
Selangor Darul Ehsan
Phone: +60-3-7952 5324 (direct)
Phone: +60-3-7952 5555 (switchb.)
Fax: +60-3-7957 0380

New Zealand
Siemens Ltd. PTD
55 Hugo Johnson Drive
Auckland
Phone: +64-9-580 5500
Fax: +64-9-580 5601

Pakistan
Siemens Pakistan Engineering
Co. Ltd. PTD
B-72, Estate Avenue, S.I.T.E.
Karachi 75700, Pakistan
Phone: +92-21-2566 213
Fax: +92-21-2566 215

Philippines
Siemens Inc., PTD
169 H.V. De la Costa Street,
Salcedo Village - Makati
1227 Manila
Phone.: +63-2-814 9017
Fax: +63-2-814 9014

Singapore
Power Automation PTE
28 Ayer Rajah Crecent
05-02/03
Singapore 139959
Phone.: +65-6872 2688
Fax: +65-6872 3692

Taiwan
Siemens Ltd., PT & D
3, Yuan Qu Street
Nan Gang District, 8F-1
115 Taipei, Taiwan R.O.C.
Phone.: +886-2-2376 1829
Fax: +886-2-2378 6430

Thailand
Siemens Limited, PTD EA
Charn Issara Tower II,
2922/283 New Petchburi Road
Bangkapi, Huay Kwang
Bangkok 10310
Phone.: +66-2-715-4771
Fax: +66-2-715-4701

Vietnam
Siemens Ltd. PTD-EA
The Landmark Building,
2nd Floor
5B Ton Duc Thang St.
District 1
Ho Chi Minh City
Phone.: +84-8-825 1900
Fax: +84-8-825 1580

Middle East

United Arab Emirates
Siemens AG, PTD EA
Level 15, Al Otaiba Tower
Sheikh Zayed 2nd Street
P.O.Box 47015
Abu Dhabi
Phone: +971-2-6165 145
Fax: +971-2-6165 122

Saudi Arabia
Siemens Ltd. PTD
Jeddah Head Office
P.O. Box 4621
21412 Jeddah
Phone: +966 2 665 8420
Fax: +966 2 665 8490

Kuwait
Siemens Electrical and
Electronic Services K.S.C.
Jaber Al-Mubarak Street,
Block 4
Sharq Kuwait City
Phone: +965-241-8888 ext. 211
Fax: +965-246-3222

Iran
Siemens SSK, PTD EA
No. 32, A. Taleghani Ave.
P.O.Box 15875 - 4773
Teheran
Phone: +98-21-6614 2123
Fax: +98-21-6646 2951

PTD EA 11.05

Notes

If not stated otherwise on the individual pages of this catalog, we reserve the right to include modifications, especially regarding dimensions and weights.

Drawings are not binding.

All product designations used are trademarks or product names of Siemens AG or other suppliers.

If not stated otherwise, all dimensions in this catalog are given in mm/inch.

The information in this document contains general descriptions of the technical options available, which do not always have to be present in individual cases. The required features should therefore be specified in each individual case at the time of closing the contract.

Printed in Italy
KGK 0106 6.0 924 En 101625 C6032

Published by

Siemens Aktiengesellschaft

Power Transmission and Distribution
Energy Automation Division
Postfach 48 06

90026 Nuernberg
Germany

www.siemens.com/energy

Order No.: E50001-K4400-A101-A4-7600